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(54) A surface-emitting organic light-emitting diode

(57) An transparent cathode includes an electron injector, a metal layer over the injector, and transparent layer deposited over the metal layer and having a refractive index equal to or greater than 1.2.

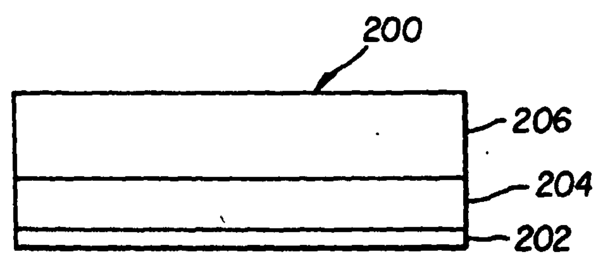

FIG. 2

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to transparent electron-injecting electrodes which are particularly, effective for use with surface-emitting organic light-emitting diodes.

BACKGROUND OF THE INVENTION

[0002] Conventional organic light-emitting diodes (OLED) has a transparent substrate, typically indium-tin-oxide (ITO) glass, through which the light is emitted, and the surface electrode such as MgAg is normally opaque. Surface-emitting OLED structure is of considerable interest in many display applications where high-resolution is desirable. Such a surface-emitting structure is definitely required for an active-matrix OLED display fabricated on a Si substrate, which has an important advantage of having on-chip data and scan drivers, allowing for ultra-high pixel resolution (<10 microns). Despite such importance, there was only limited success in fabricating a suitable transparent top electrode.

[0003] G. Gu and others reported an OLED structure with a transparent top electrode consisting of a thin MgAg layer and a thicker overlying ITO film. See "Transparent organic light emitting devices" by G. Gu, V. Bulovic, P. E. Burrows, S. R. Forrest, and M. E. Thompson in Appl. Phys. Lett. 68, 2606 (1996). When ITO was deposited using a conventional sputtering process, the resulting OLED was often leaky, indicative of inter-electrode shorts. Furthermore, the forward device current was substantially lower than that of a conventional device with a thermally evaporated thick MgAg cathode. A low sputtering power of 5 W for ITO was found necessary to produce functional OLEDs without excessive shorts. However, the sputtering rate (about 0.3 nm/min) was exceedingly slow because of the low sputtering power used.

[0004] More recently, Parthasarathy and others, and Hung and others. introduced a new transparent top electrode structure employing a thin film of copper phthalocyanine (CuPc) instead of MgAg, overlaid by a sputter-deposited ITO film. See "A metal-free cathode for organic semiconductor devices" by G. Parthasarathy, P. E. Burrows, V. Khalfin, V. G. Kozlov, and S. R. Forrest, in Appl. Phys. Lett. 72, 2138 (1998) and see " Interface engineering in preparation of organic surface-emitting diodes" by L. S. Hung and C. W. Tang in Appl. Phys. Left. 74, 3209 (1999). The CuPc apparently acts as a buffer in reducing the shorting problem caused by the ITO sputtering process. However, the CuPc layer forms an electron-injection barrier with the Alq layer, resulting in increased electron-hole recombination in the non-emissive CuPc layer, and thus a substantial reduction in EL fficiency. Incorporation of Li at the CuPc/Alq interface was necessary to reduce the injection barrier at the interface and recover the device efficiency.

[0005] Since OLEDs are extremely sensitive to radiation, the use of a sputter-deposited ITO film to form a transparent top electrode not only increases the complexity of electrode preparation, but also introduces substantial radiation damage to OLEDs, thus resulting in device shorts and severe degradation of device performance. The use of a buffer layer is not sufficient to completely resolve the problems, and makes the process more difficult for manufactory.

SUMMARY OF THE INVENTION

[0006] It is the object of this invention to provide a multilayer structure, which is highly transmissive and acts as an effective electron-injecting electrode in OLEDs.

[0007] This object is achieved by a transparent cathode comprising:

(a) an electron injector;
(b) a metal layer over the injector; and
(c) a transparent layer deposited over the metal layer and having a refractive index equal to or greater than 1.2.

[0008] The disclosed structure in this invention can be prepared by conventional thermal evaporation in one pump-down, so that the process is significantly simplified and no radiation damage is introduced during deposition. The efficient metal-organic contact and the highly conductive metal layer ensure device operation at low voltages. As a result, the surface-emitting OLEDs have superior electrical and optical characteristics and are readily fabricated at a high short-free yield.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a schematic diagram of a prior art organic surface-emitting device in which light is emitted through a thin MgAg cathode and an ITO outer layer;
FIG. 2 is a schematic diagram of an embodiment of the multilayer transparent cathode of the invention;
FIG. 3 shows the calculated transmittance of the multilayer cathode as a function of refractive index of the top layer;
FIG. 4 is a schematic diagram of an embodiment of the surface-emitting organic light-emitting diodes of the invention;
FIG. 5 shows electrical characteristics of the surface-emitting organic light-emitting diodes of the invention and the prior art;
FIG. 6 shows optical characteristics of the surface-

emitting organic light-emitting diodes of the invention and the prior art;

FIG. 7 shows lectrical characteristics of the surface-emitting organic light-emitting diodes of the invention. The properties of the devices with a different cathode structure (Ag/MgO, LiF/Al/MgO, and LiF/Al/Ag) are displayed in the figure for comparison; and

FIG. 8 shows optical characteristics of the surface-emitting organic light-emitting diodes of the invention. The properties of the devices with a different cathode structure (Ag/MgO, LiF/Al/MgO, and LiF/Al/Ag) are displayed in the figure for comparison.

[0010] The drawings are necessarily of a schematic nature, since the thicknesses of the individual layers are too thin, and thickness differences of the various elements too great to permit depiction to scale or to permit convenient proportionate scaling.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Before describing the multilayer cathode and the surface-emitting OLEDs of the invention, one configuration of prior art surface-emitting OLED will be discussed.

[0012] In FIG. 1, an organic light-emitting device 100 has a light-transmissive substrate 102 on which is disposed a light-transmissive anode 104. An organic light-emitting structure 120 is formed between the anode 104 and a cathode 110. The organic light-emitting structure 120 includes in sequence, an organic hole-transporting layer 122, an organic light-emitting layer 124, and an organic electron-transporting layer 126. The cathode structure 110 is comprised, in sequence, a thin MgAg layer 112 and a sputter-deposited ITO layer 114. When an electrical potential difference (not shown) is applied between the anode 104 and the cathode 110 such that the anode is at a more positive electrical potential with respect to the cathode, the cathode will inject electrons into the electron-transporting layer 126, and holes will be injected from the anode 104 into the hole-transporting layer 122. Hole-electron recombination occurs in the light-emitting layer 124, and energy is released as light, which is emitted through the light-transmissive anode 104 and substrate 102 as well as through the cathode 110. When an opaque substrate is used and a high-work function metal is serving as an anode, light is emitted only from the top cathode 110.

[0013] Turning now to FIG. 2, a multilayer transparent cathode 200 of the invention has, in order, an efficient electron injecting layer 202, a conductive and semi-transparent metal layer 204 over the electron injector, and a transparent layer 206 overlaid on the metal layer. The transparent layer has a reflective index equal to or greater than 1.2.

[0014] The electron injector 202 can be formed by depositing a metal layer having a work function of less than 4 eV on the organic electron-transporting layer. The electron injector metal is selected from the group consisting of alkali, alkaline earth, and rare earth metals. The alkali metal includes lithium, sodium, potassium, rubidium, or cesium. The alkaline earth metal includes magnesium, calcium, strontium, or barium. The rare earth metal includes cerium, neodymium, samarium, europium, gadolinium, or terbium. The thickness of the low-work-function metal layer is in the range of 0.2 to 2.0 nm.

[0015] The electron injector 202 can also be formed by depositing a 2-layer cathode on the electron-transporting layer. The 2-layer cathode is consisting of a thin inner layer of metal fluorides or oxides and a thin Al outer layer. The metal fluoride layers can be selected from alkali fluorides or alkaline earth fluorides. The metal oxide layers can be selected from alkali oxides or alkaline earth oxides. The alkali fluoride includes lithium fluoride, sodium fluoride, potassium fluoride, rubidium fluoride, or cesium fluoride; and the alkali oxide includes lithium oxide, sodium oxide, potassium oxide, rubidium oxide, or cesium oxide. The alkaline earth fluoride includes magnesium fluoride, calcium fluoride, strontium fluoride, or barium fluoride; and the alkaline earth oxide includes magnesium oxide, calcium oxide, strontium oxide, or barium oxide. The thickness of the fluoride or oxide layer is in the range of 0.2 to 2.0 nm, and the thickness of the Al layer is in the range of 0.2 to 4.0 nm.

[0016] The conductive and semi-transparent metal layer 204 can be selected from the group consisting of silver, gold, copper, and their alloys. These materials have low electric resistivities, thus substantially reducing the sheet resistance of cathodes. The thickness of the metal layer is in the range of 5-40 nm in order to form a continuous layer and offer a high transmittance to visible light.

[0017] However, due to the high reflectance of the metal layers it is necessary to use a transparent overcoating layer 206 which has a refractive index equal to or greater than 1.2 to reduce reflectance and thus enhance light transmission through the cathode. Computer simulation was utilized to determine light transport through two structures. The first structure is consisting of an electron injecting layer and a 20-nm thick silver layer. The second structure is consisting of an electron injecting layer, a 20-nm thick silver layer, and a 55-nm magnesium oxide layer. In both cases, the electron injecting layer was made of a 0.3-nm LiF layer and a 0.6-nm Al layer. The optical properties of the two structures were calculated as a function of light wavelength. The first structure exhibits high reflectance and low transmittance. For instance, at 550 nm (corresponding to green light) th first structure approximately shows a reflectance of 60% and a transmittance of 30%. It is of interest to note that the addition of a magnesium oxide

layer on the first structure substantially reduces light reflectance, and correspondingly increases the transmittance. For instance, at 550 nm the reflectance is reduced from 60% to 30%, and correspondingly the transmittance is incr ased from 30% to 60%. The improvement of light transmission can also be achieved when replacing the magnesium oxide layer by other materials with a relatively large reflective index. FIG. 3 shows how the transmittance varies with reflective index of the transparent layers. Therefore, any transparent materials with a reflective index equal to or greater than 1.2 can be selected to form the multilayer cathode. The materials can be selected from the group consisting of fluorides, oxide, and selenide. The fluoride includes lithium fluoride, magnesium fluoride, calcium fluoride, strontium fluoride, or barium fluoride. The oxide includes silicon oxide, magnesium oxide, indium oxide, tin oxide, zinc oxide, or zirconium oxide. The selenide includes zinc selenide or sulfur selenide.

[0018] Besides the listed inorganic transparent dielectric materials in FIG. 3, the materials can be organic materials as well, as long as the materials is transparent at the wavelength of interest and their refractive indices of the materials are equal to or greater than 1.2. For instance, α-napthylphenylbiphenyl diamine (NPB) and Tris-(8-hydroxyquinoline) aluminum (Alq) are suitable for this application.

[0019] In FIG. 4, a surface-emitting organic light-emitting diode 400 is illustrative which is formed in accordance with the present invention. Here the device 400 has a substrate 402, on which is disposed an anode 404. An organic light-emitting structure 420 is formed between the anode 404 and a cathode 410. The organic light-emitting structure 420 is comprised of, in sequence, an organic hole-transporting layer 422, an organic light-emitting layer 424, and an organic electron-transporting layer 426. The structure is distinct over the prior art of FIG. 1, as the cathode 410 is formed of a thin electron injecting layer 412, a semi-transparent metal layer 414, and a transparent layer 416 having a refractive index of 1.2 at least; and no sputtering is employed for film deposition. When an electrical potential difference (not shown) is applied between the anode 404 and the cathode 410 such that the anode is at a more positive electrical potential with respect to the cathode, the cathode 410 will inject electrons into the electron-transporting layer 426, and holes will be injected from the anode 404 into the hole-transporting layer 422. Hole-electron recombination occurs in the light-emitting layer 424, and energy is released as light, which is emitted through the light-transmissive anode 404 and substrate 402 as well as through the cathode 410. When an opaque substrate is used and a high-work function metal is serving as an anode, light is emitted only from the top cathode 410.

[0020] The substrate 402 are electrically insulated and can either b light transmissive or opaque. Th light transmissive property is desirable for viewing the EL emission through both the bottom and the top surface. For applications where the EL emission is viewed through the top electrode, the transmissive characteristic of the support is immaterial, and therefore any appropriate substrate such as opaque semiconductor and ceramic wafers can be used.

[0021] Substrate 402 can be a transmissive substrate selected from the group of glass and plastic foil. It can be an opaque substrate, such as a single crystal semiconductor substrate selected from the group consisting of Si, Ge, GaAs, GaP, GaN, GaSb, InAs, InP, InSb, and $Al_xGa_{l-x}As$, where x is from 0 to 1. Substrate 402 can be either undoped, lightly doped, or heavily doped. Substrate 402 is either bare or covered with a layer of dielectric material such as Si oxides or Si nitrides. In some applications, part of the semiconductor can be used as substrate 402 for electroluminescent devices, while the remainder of the semiconductor wafer can be processed to form drivers, switchers, or other electronic devices.

[0022] The anode 404 is formed of a conductive and transmissive layer. The light transparent property of the layer 404 is desirable for viewing the EL emission through the substrate and the top electrode. For applications where the EL emission is viewed through the top electrode, the transmissive characteristic of the layer 404 is immaterial, and therefore any appropriate materials such as metals or metal compounds having a work function greater than 4.2 eV can be used. The metal includes gold, iridium, molybdenum, palladium, or platinum. The conductive and transmissive layer can be selected from the group consisting of metal oxides, nitrides such as gallium nitride, selenides such as zinc selenide, and sulphides such as zinc sulphide. The suitable metal oxides include indium-tin oxide, aluminum- or indium-doped zinc oxide, tin oxide, magnesium-indium oxide, nickel-tungsten oxide, or cadmium-tin oxide.

[0023] The hole transporting layer of the organic EL device 422 contains at least one hole transporting aromatic tertiary amine, where the latter is understood to be a compound containing at least one trivalent nitrogen atom that is bonded only to carbon atoms, at least one of which is a member of an aromatic ring. In one form the aromatic tertiary amine can be an arylamine, such as a monarylamine, diarylamine, triarylamine, or a polymeric arylamine. Exemplary monomeric triarylamines are illustrated by Klupfel and others US-A-3,180,730. Other suitable triarylamines substituted with vinyl or vinyl radicals and/or containing at least one active hydrogen containing group are disclosed by Brantley and others US-A-3,567,450 and US-A-3,658,520.

[0024] The luminescent layer 424 of the organic EL device includes a luminescent or fluorescent material, where electroluminescence is produced as a result of electron-hole pair recombination in this region. In the simplest construction, the luminescent layer comprises of a single component, that is a pure mat rial with a high fluorescent efficiency. A well known material is tris

(8-quinolinato) aluminum, (Alq), which produces excellent green electroluminescenc . A preferred embodiment of the luminescent layer comprises a multi-component mat rial consisting of a host material doped with one or more components of fluorescent dyes. Using this method, highly efficient EL devices can be constructed. Simultaneously, the color of the EL devices can be tuned by using fluorescent dyes of different emission wavelengths in a common host material. This dopant scheme has been described in considerable details for EL devices using Alq as the host material by Tang and others in commonly-assigned US-A-4,769,292.

[0025] Preferred materials for use in forming the electron transporting layer 426 of the organic EL devices of this invention are metal chelated oxinoid compounds, including chelates of oxine itself (also commonly referred to as 8-quinolinol or 8-hydroxyquinoline). Such compounds exhibit both high levels of performance and are readily fabricated in the form of thin layers.

[0026] The multilayer transparent cathode of the invention can have applications in other electroluminescent devices. One of the potential applications is the use of such structures in polymer light-emitting diodes.

EXAMPLES

[0027] The following examples are presented for a further understanding of the invention. For purposes of brevity, the materials and the layers formed therefrom will be abbreviated as given below:

ITO	: indium tin oxide (anode)
NPB	: 4,4'-bis-[N-(1-naphthyl)-N-phenylamino]-biphenyl (hole-transporting layer)
Alq	: tris (8-quinolinolato-N1, 08)-aluminum (electron-transporting layer; functioning here as a combined light-emitting layer and electron-transporting layer)
MgAg	: magnesium: silver at a ratio of 10:1 by volume (cathode)
MgO	: magnesium oxide (deposited on Ag to reduce light reflection)
Ag	: silver (deposited on Al to reduce sheet resistance of cathodes)
Al	: aluminum (deposited on LiF)
LiF	: lithium fluoride (disposed over electron-transporting layer and combined with Al to form a electron injector))

Preparation of an organic light-emitting structure:

[0028] An organic light-emitting structure was constructed in the following manner:

(a) a light-transmissive anode of ITO-coat d glass was ultrasonicated in a commercial detergent, rinsed in deionized wat r, degreased in toluene vapor, and contacted by a strong oxidizing agent;

(b) a 75 nm thick NPB hole-transporting layer was deposited on the ITO-glass by conventional thermal vapor deposition; and

(c) a 75 nm thick Alq electron-transporting and light-emitting lay r was deposited on the NPB layer by conventional thermal vapor deposition.

[0029] The above structure serves as a base configuration for each of the following examples, and is given in abbreviated form as ITO/NPB(75)/Alq(75).

Example A

[0030] An organic light-emitting device was constructed as follows: a MgAg cathode was deposited on the Alq (75) layer of the base configuration by conventional thermal vapor deposition from two sources (Mg & Ag) to a thickness of about 200 nm, so as to produce a control device having an opaque top electrode.

Example B

[0031] An organic light-emitting device was constructed as follows: a MgAg cathode was deposited on the Alq (75) layer of the base configuration by conventional thermal vapor deposition from two sources (Mg & Ag) to a thickness of about 10 nm, and then an ITO layer was overlaid on the thin MgAg buffer layer by radio frequency sputtering so as to provide a prior art device.

Example C

[0032] An organic light-emitting device was constructed as follows: an Ag layer was deposited on the Al (q) layer of the base configuration by conventional thermal vapor deposition to a thickness of 20 nm, and then a MgO layer was deposited on the Ag layer to a thickness of 56 nm.

Example D

[0033] An organic light-emitting device was constructed as follows: a LiF layer was deposited on the Al (q) layer of the base configuration by conventional thermal vapor deposition to a thickness of 0.3 nm, an Al layer with a thickness of 0.6 nm was deposited on the LiF layer, and then a MgO layer was deposited on the Al layer to a thickness of 56 nm.

Example E

[0034] An organic light-emitting device was constructed as follows: a LiF layer was deposited on the Al (q) layer of the base configuration by conventional thermal vapor deposition to a thickness of 0.3 nm, an Al layer with a thickness of 0.6 nm was deposited on the LiF layer, and then an Ag layer was deposited on the LiF

layer to a thickness of 20 nm.

Example F

[0035] An organic light-emitting device was constructed as follows: a LiF layer was deposited on the Al (q) layer of the base configuration by conventional thermal vapor deposition to a thickness of 0.3 nm, an Al layer with a thickness of 0.6 nm was deposited on the LiF layer, a silver layer with a thickness of 20 nm was deposited on the LiF layer, and then a MgO layer was deposited on the silver layer to a thickness of 56 nm.

Example G

[0036] An organic light-emitting device was constructed as follows: a LiF layer was deposited on the Al (q) layer of the base configuration by conventional thermal vapor deposition to a thickness of 0.3 nm, an Al layer with a thickness of 0.6 nm was deposited on the LiF layer, a silver layer with a thickness of 20 nm was deposited on the LiF layer, and then an Alq layer was deposited on the silver layer to a thickness of 100 nm.

[0037] Electrical shorts were commonly observed in Example B, but the inter-electrode shorting was not observed in Examples F and G. The shorts were apparently caused by radiation damage during sputtering deposition of ITO. Each of the devices was tested by applying a drive voltage between the anode and cathode, such that the anode was positive with respect to the cathode. A current-drive voltage relationship and a current-luminance relationship were then determined, and the results are shown in FIGS 5-8.

[0038] Viewing FIGS. 5 and 6, it is apparent that the surface-emitting OLED of the invention exhibits better electrical and optical characteristic than that the prior art. For instance, the voltage required to reach a current density of 100 mA/cm is 8.5 V and 12.2 V for the devices of Examples F and B, respectively. Furthermore, at 100 mA/cm^2 the luminance of the light emitted from the top electrode with a reflective coating layer on ITO-glass is 2640 cd/m^2 and 1840 cd/m^2 for the devices of Examples F and B, respectively.

[0039] In FIGS. 7 and 8 the results obtained from Examples F, C, D and E are shown. It is clear that both electrical and optical characteristics of the surface-emitting OLED of the invention are much better than those measured on the devices with a different cathode configuration of Ag/MgO, LiF/Al/MgO, or LiF/Al/Ag. The device of Example C requires a much higher operating voltage than the device of Example F and exhibits a much lower electroluminescence efficiency due to the high-work-function material Ag used as an electron injector. For Example D, neither current nor luminance was detected at an operating voltage up to 20 V because the high resistive cathode blocked current transport. The current-voltage curv of Example E was identical to that of Example F, however, its electroluminescence efficiency was approximately 60-70% of the valu measure on the device of Example F because of high reflectance of the cathode structure.

[0040] The results obtained from the device of Example G are very similar to those from the device of Example F. Thus it indicates that the transparent overcoating layer can be selected from both inorganic and organic materials.

[0041] Other features of the invention are included below.

[0042] The transparent cathode wherein the thickness of the low-work-function metal layer is in the range of 0.2 to 2.0 nm.

[0043] The transparent cathode wherein the electron injector is formed of a 2-layer structure.

[0044] The transparent cathode of the 2-layer structure is consisting of a thin metal fluoride layer and a thin Al outer layer.

[0045] The transparent cathode wherein the metal fluoride can be selected from the group consisting of alkali and alkaline earth fluorides.

[0046] The transparent cathode wherein the alkali fluoride includes lithium fluoride, sodium fluoride, potassium fluoride, rubidium fluoride, or cesium fluoride.

[0047] The transparent cathode wherein the alkaline earth fluoride includes magnesium fluoride, calcium fluoride, strontium fluoride, or barium fluoride.

[0048] The transparent cathode wherein the thickness of the fluoride layer is in the range of 0.2 to 2.0 nm, and the thickness of the Al layer is in the range of 0.2 to 4.0 nm.

[0049] The transparent cathode wherein the 2-layer structure is consisting of a thin metal oxide layer and a thin Al outer layer.

[0050] The transparent cathode wherein the metal oxide is selected from the group consisting of alkali and alkaline earth oxides.

[0051] The transparent cathode wherein the alkali oxide includes lithium oxide, sodium oxide, potassium oxide, rubidium oxide, or cesium oxide.

[0052] The transparent cathode wherein the alkaline earth oxide includes magnesium oxide, calcium oxide, strontium oxide, or barium oxide.

[0053] The transparent cathode wherein the thickness of the oxide layer is in the range of 0.2 to 2.0 nm, and the thickness of the Al layer is in the range of 0.2 to 4.0 nm.

[0054] The transparent cathode wherein the metal layer is conductive and semi-transparent.

[0055] The transparent cathode wherein the metal layer is selected from the group consisting of silver, gold, copper, and their alloys.

[0056] The transparent cathode wherein the thickness of the metal layer is in the range of 5-40 nm.

[0057] The transparent cathode wherein the transpar nt layer is selected from the group consisting of inorganic and organic materials.

[0058] The transparent cathode wherein the inor-

ganic material is selected from the group consisting of fluoride, oxide, and selenide.

[0059] The transparent cathode wherein the fluoride includes lithium fluoride, magnesium fluoride, calcium fluoride, strontium fluoride, or barium fluoride.

[0060] The transparent cathode wherein the oxide includes silicon oxide, magnesium oxide, indium oxide, tin oxide, zinc oxide, or zirconium oxide.

[0061] The transparent cathode wherein the selenide includes zinc selenide or sulfur selenide.

[0062] The transparent cathode wherein the organic material includes napthylphenylbiphenyl diamine (NPB) and Tris-(8-hydroxyquinoline) aluminum (Alq).

[0063] The surface-emitting organic light-emitting diode wherein the substrate is electrically insulated and is light transmissive or opaque.

[0064] The surface-emitting organic light-emitting diode wherein the light transmissive substrate is selected from the group consisting of glass and plastic foil.

[0065] The surface-emitting organic light-emitting diode wherein the light opaque substrate can be a single crystal semiconductor substrate selected from the group consisting of Si, Ge, GaAs, GaP, GaN, GaSb, InAs, InP, InSb, and $Al_xGa_{l-x}As$, where x is from 0 to 1.

[0066] The surface-emitting organic light-emitting diode wherein the anode is a conductive and transmissive layer formed from metal oxides.

[0067] The surface-emitting organic light-emitting diode wherein the oxide includes indium-tin oxide, aluminum- or indium-doped zinc oxide, tin oxide, magnesium-indium oxide, nickel-tungsten oxide, or cadmium-tin oxide.

[0068] The surface-emitting organic light-emitting diode wherein the anode is a conductive and opaque layer formed from metal or metal alloys.

[0069] The surface-emitting organic light-emitting diode wherein the metal and metal alloy include nickel, gold, iridium, molybdenum, palladium, or platinum.

[0070] The surface-emitting organic light-emitting diode wherein the organic hole-transporting layer is formed of a material including hole-transporting aromatic tertiary amine molecules.

[0071] The surface-emitting organic light-emitting diode wherein the organic light-emitting layer is formed of a light-emitting host material consisting of a metal chelated oxinoid compound.

[0072] The surface-emitting organic light-emitting diode wherein the organic light-emitting layer further includes at least one dye which emits light when dispersed in the light-emitting host material.

[0073] The surface-emitting organic light-emitting diode wherein the electron-transporting layer is formed of a material consisting of a m tal chelated oxinoid compound.

Claims

1. A transparent cathode comprising:

    (a) an electron injector;
    (b) a metal layer over the injector; and
    (c) a transparent layer deposited over the metal layer and having a refractive index equal to or greater than 1.2.

2. The transparent cathode of claim 1 wherein the electron injector is formed of a metal having a work function of less than 4 eV.

3. The transparent cathode of claim 2 wherein the electron injector metal is selected from the group consisting of alkali, alkaline earth, and rare earth metals.

4. The transparent cathode of claim 3 wherein the alkali metal includes lithium, sodium, potassium, rubidium, or cesium.

5. The transparent cathode of claim 3 wherein the alkaline earth metal includes magnesium, calcium, strontium, or barium.

6. The transparent cathode of claim 3 wherein the rare earth metal includes cerium, neodymium, samarium, europium, gadolinium, or terbium.

7. A surface-emitting organic light-emitting diode comprising:

    (a) a substrate formed of an electrically insulating material;
    (b) a conductive anode mounted over the substrate;
    (c) an organic light-emitting structure formed over the anode layer; and
    (d) a transparent cathode formed over the organic light-emitting structure and including:

        (i) an electron injector,
        (ii) a metal layer over the electron injector; and
        (iii) a transparent layer overlaid on the metal layer and having a reflective index equal to or greater than 1.2.

8. The surface-emitting organic light-emitting diode of claim 7 wherein the organic light-emitting structure includes:

    (a) an organic hole-transporting layer formed over the anode layer;
    (b) an organic light-emitting layer formed over the hole-transporting layer; and

(c) an organic electron-transporting layer form d over the light-emitting layer.

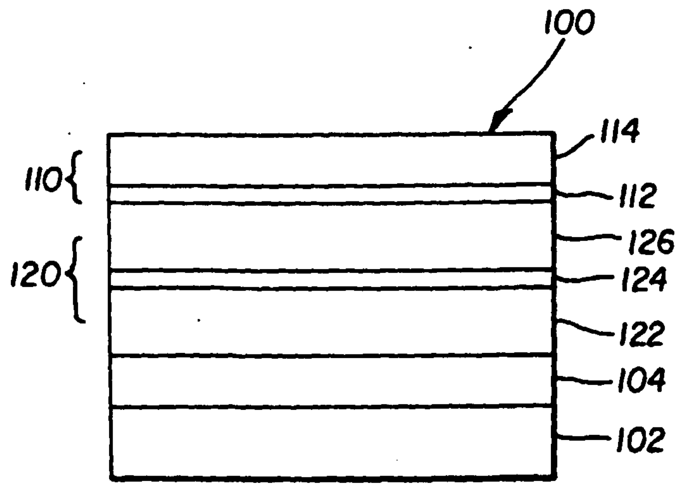


FIG. 1

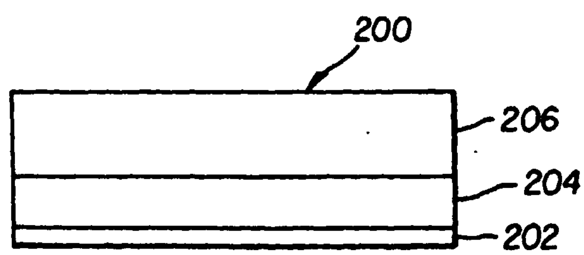


FIG. 2

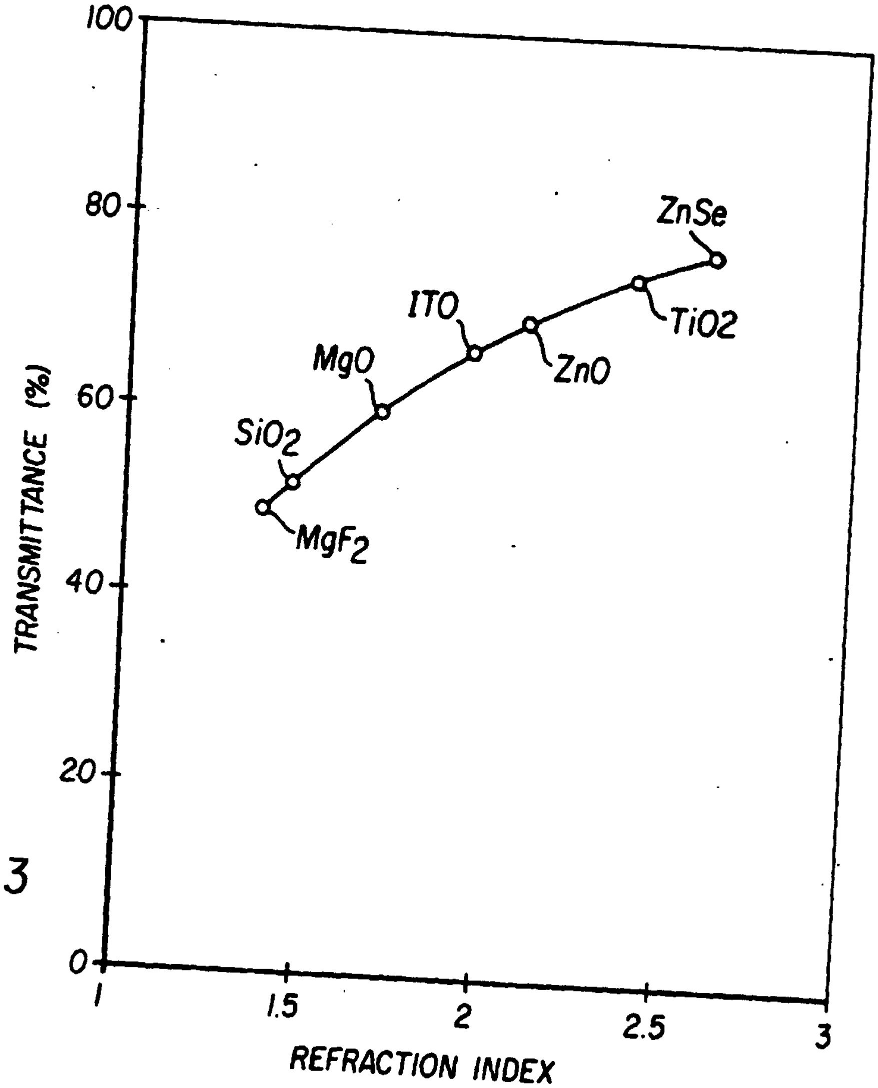
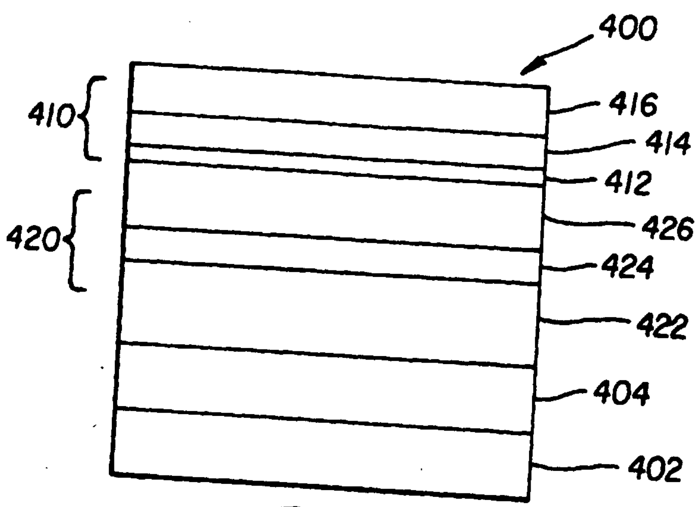

100
80
60
40
20
0
1
1.5
2
2.5
3
TRANSMITTANCE (%)
REFRACTION INDEX
ZnSe
TiO2
ITO
ZnO
MgO
SiO2
MgF2

FIG. 3


400
416
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420

FIG. 4

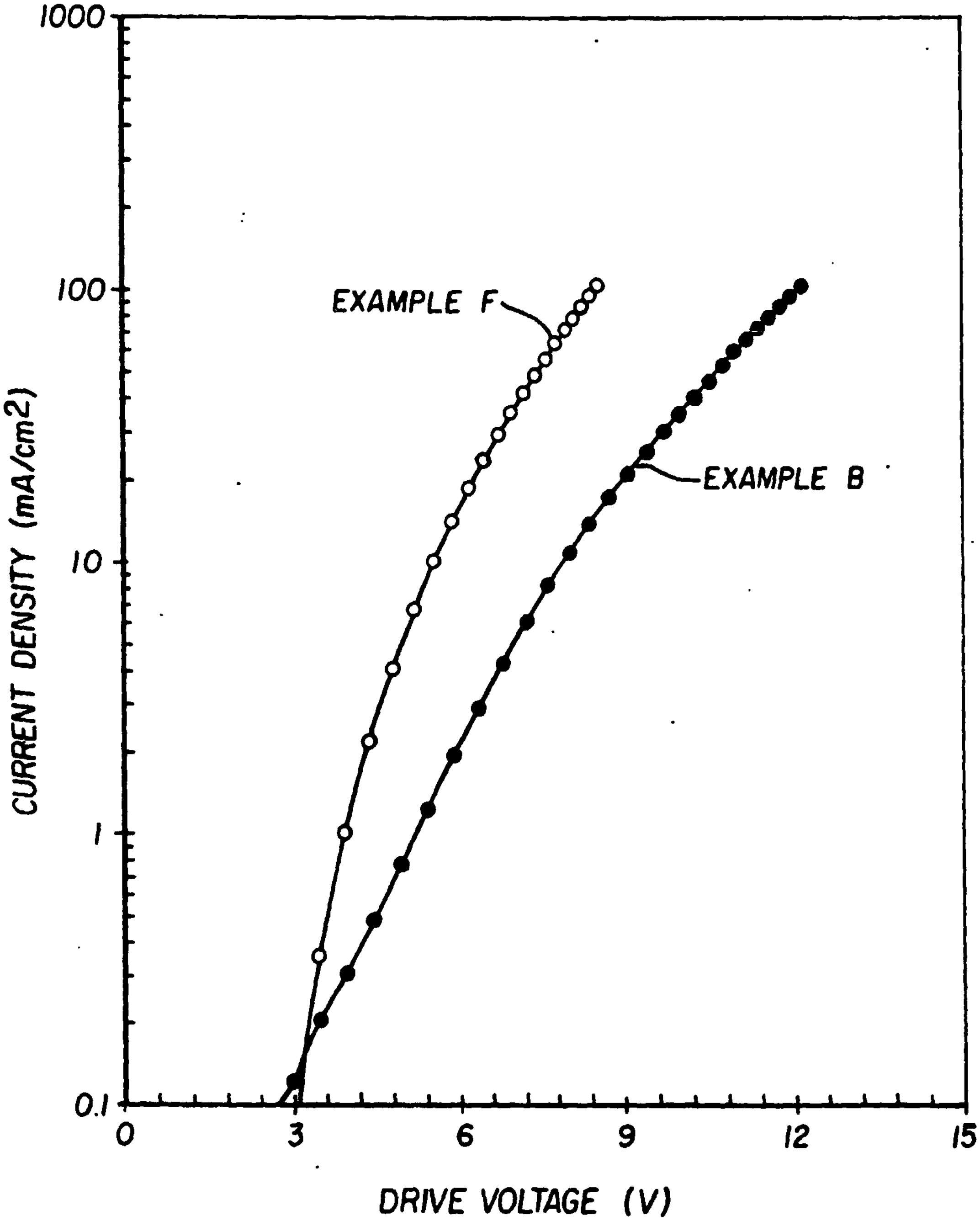

1000
100
10
1
0.1
CURRENT DENSITY (mA/cm2)
0
3
6
9
12
15
DRIVE VOLTAGE (V)
EXAMPLE F
EXAMPLE B

FIG. 5

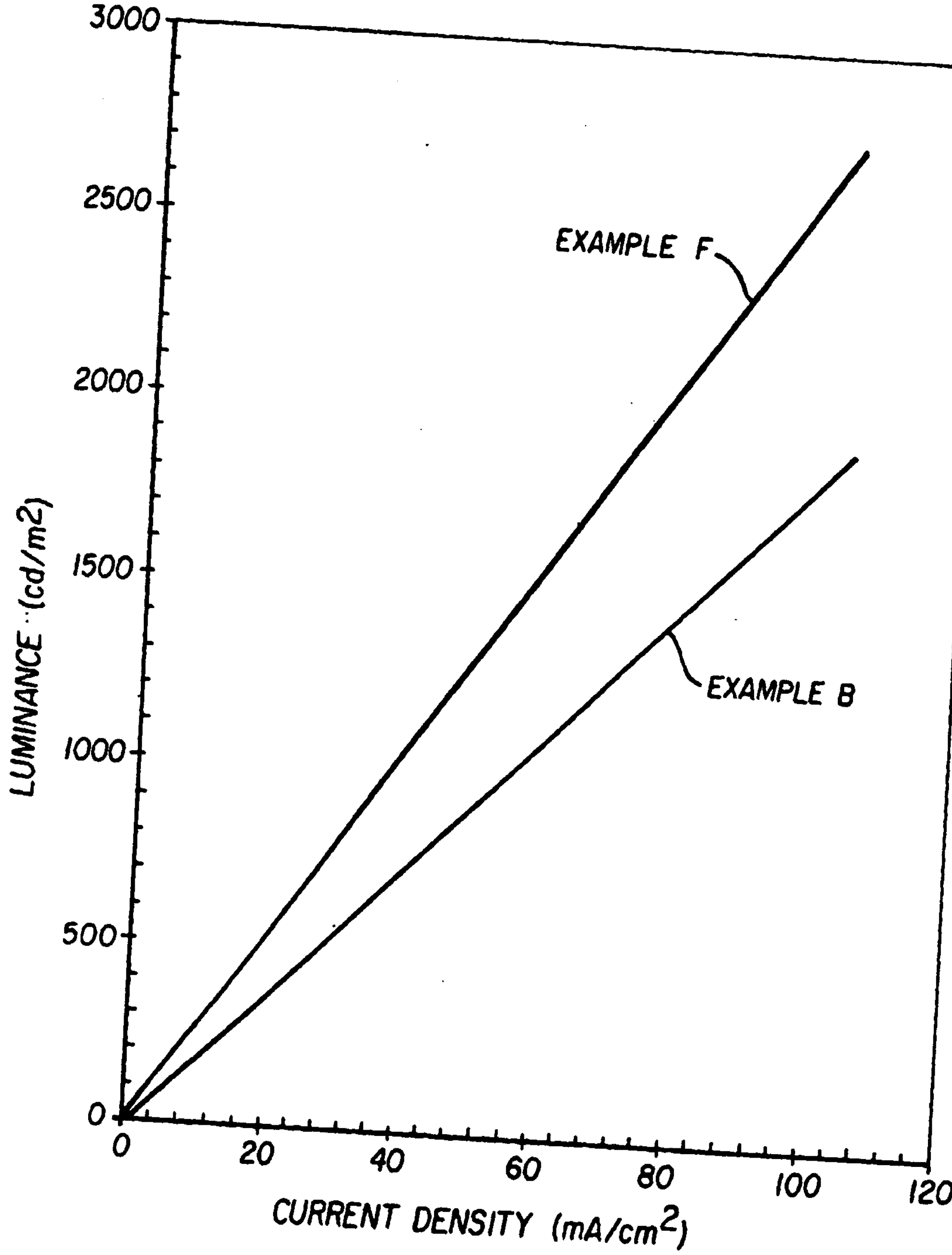
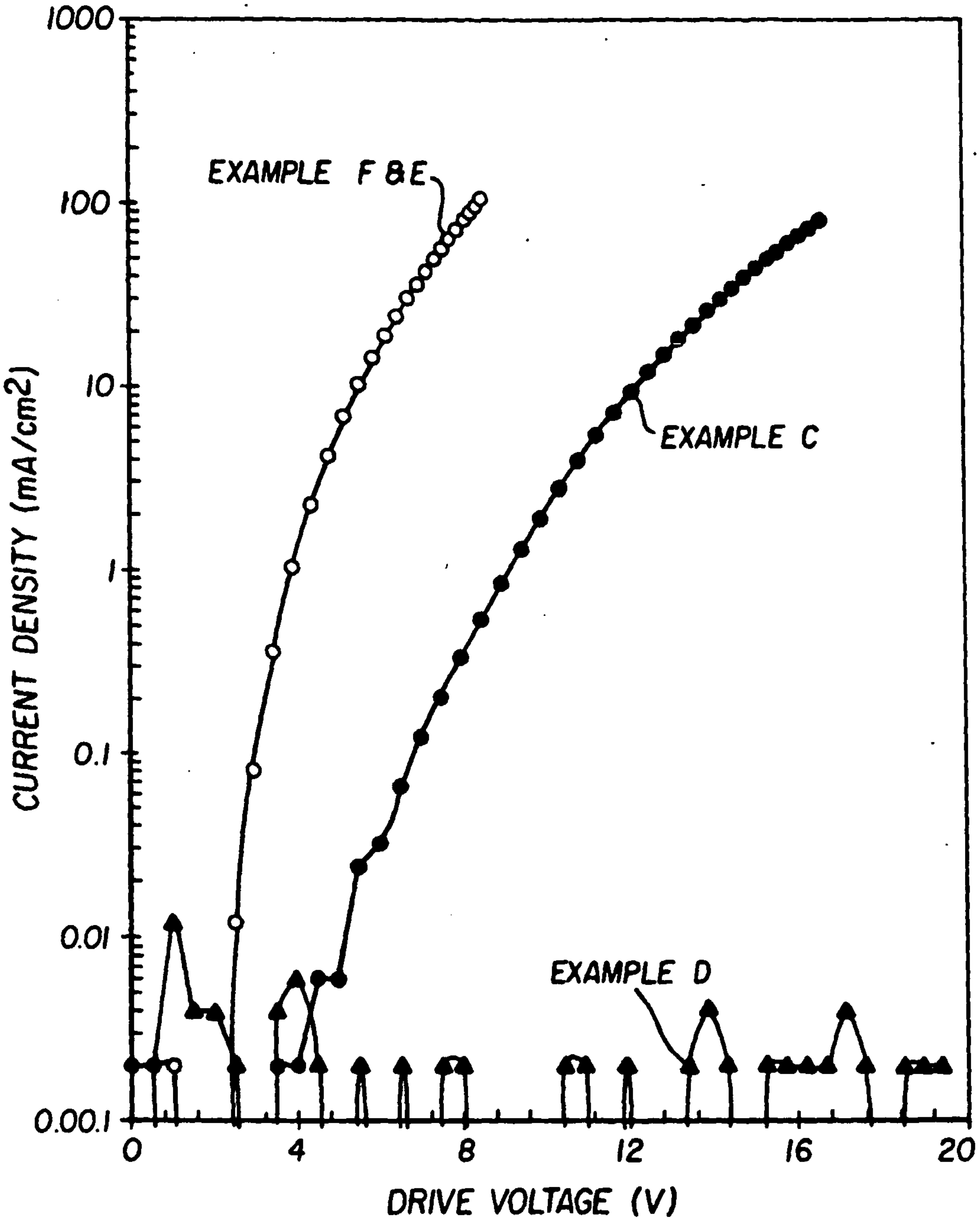

3000
2500
2000
1500
1000
500
0
LUMINANCE (cd/m2)
0
20
40
60
80
100
120
CURRENT DENSITY (mA/cm2)
EXAMPLE F
EXAMPLE B

FIG. 6



1000
100
10
1
0.1
0.01
0.00.1
CURRENT DENSITY (mA/cm2)
EXAMPLE F & E
EXAMPLE C
EXAMPLE D
0
4
8
12
16
20
DRIVE VOLTAGE (V)

FIG. 7

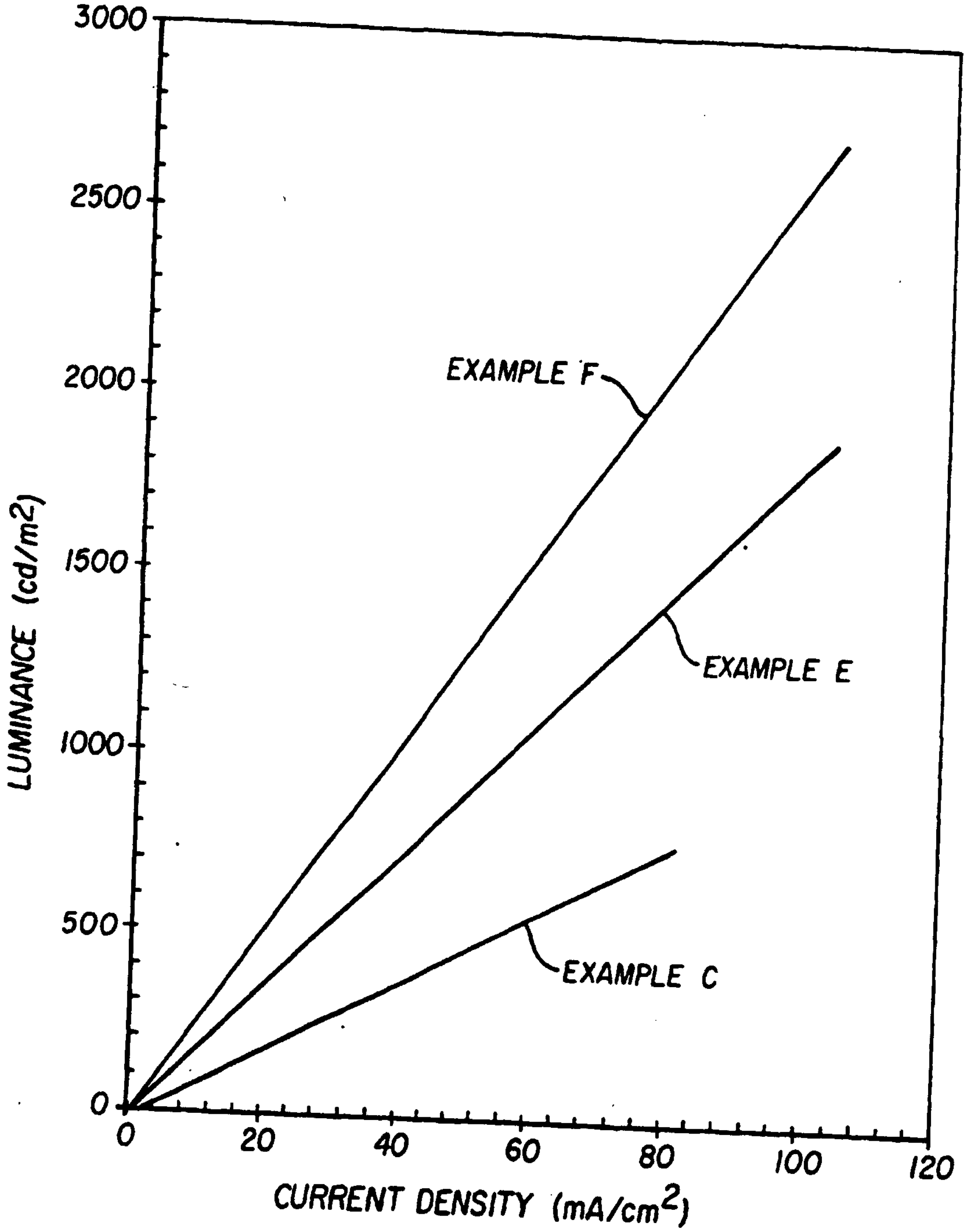

3000
2500
2000
1500
1000
500
0
LUMINANCE (cd/m2)
EXAMPLE F
EXAMPLE E
EXAMPLE C
0
20
40
60
80
100
120
CURRENT DENSITY (mA/cm2)

FIG. 8

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(54) Organic electroluminescent display panel and method for manufacturing the same

Organische Elektrolumineszenzanzeige und Verfahren zu deren Herstellung

Panneau d'affichage électroluminescent en matière organique et procédé pour sa fabrication

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EP-A- 0 550 062
EP-A- 0 639 937

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an organic electroluminescent display panel used in a display apparatus and comprising a plurality of organic electroluminescent elements (also referred to herein as EL elements) each including an emitting layer made of an organic compound material, which utilizes an electroluminescence phenomenon that is the emission of light resulting from injection of an electric current to the emitting layer. In particular, it is related to a full color display device comprising a matrix of the EL elements. More particularly, the present invention is related to an organic electroluminescent display panel of the kind as defined in the preamble of claim 1. Furthermore, the present invention relates to a method for manufacturing an organic electroluminescent display panel of the kind as defined in the preamble of claim 10. A display panel and a method of this kind is known from EP-A-0 550 062.

2. Description of the Related Art

[0002] Generally, the formations of the cathode and the organic function layers of EL media in the organic EL element are difficult in a micro-patterning art, since there are the low levels in durabilities of heat resistance (100°C or less), wet-proof and solvent-resisting of the organic EL media used for the carrier injection layers, the emitting layer or the like in the function layers. If the ordinary photolithography patterning is utilized for the formation of such function layers of the organic EL element, the solvent in the photoresist infiltrates into the function layers of the EL element to be damaged, and the organic EL element is damaged during the photoresist baking with a high temperature atmosphere, and further, the development solution or etching liquid for the photoresist layer also intrudes into the organic EL element to be damaged. Even plasma in the dry-etching for the photoresist layer damages the organic function layers of the EL element. These damages cause the deterioration in the performance of the organic EL element and emission properties. This is a serious problem.

[0003] Alternatively, there is a vacuum deposit patterning by using a shadow mask to form the cathode and the organic function layers of the organic EL element. In this case, there are many problems in that the mask comes into contact with a substrate on which the organic function layers are formed. That is, the leakage of the vapor of organic EL media occurs between the mask and the substrate due to incomplete contact thereof. Otherwise, the shadow mask is compulsorily, sealingly put into contact with the substrate. In this case, the organic EL medium is damaged due to the contact of the forced mask during the EL medium deposition, and further the cathode to be deposited is deformed by the mask to be short-circuited to the anode made of indium tin oxide (referred to herein as ITO) previously formed on the substrate. This direct contact of the mask and the substrate further causes deformities of the mask with precise fine patterns such as stripe cathode patterns because of insufficient strength of the mask with such stripe openings.

Therefore, it is very difficult to form precise fine patterns for the cathode and the organic function layers of the organic EL element.

[0004] As full color display devices, there have been known emitting devices as shown in Japanese Patent Kokai Nos. 2-66873, 5-275172, 5-258859 (cf. also EP-A-0 550 062) and 5-258860 the latter of three corresponding to U. S Patent Applications Serial Nos. 814512, 814163 (cf. also EP-A-0 550 062) and 814553 respectively. This each full color display device comprises a plurality of emitting pixels existing at intersections of lines and rows of matrix electrodes.

[0005] In the emitting device, the pixels are formed on a common transparent substrate with electrical insulation. The line electrodes made of transparent material are formed on the substrate and spaced from one another. This first transparent electrodes connect the adjacent pixels. Organic EL media are formed on the first electrodes and the substrate. The pixels include the second electrodes of row formed on the organic EL media respectively and spaced from one another. The second electrodes of row extends perpendicular to the first electrodes and connect the adjacent pixels respectively. In the emitting device, there is employed a simple matrix structure that the first and second electrodes sandwich the organic EL media at the intersections thereof.

[0006] Japanese Patent Kokai No. 2-66873 discloses a technology to avoid the forgoing problem of the infiltration of the photoresist solvent into the EL medium layer, that is, the photoresist comprising a specific solvent non-melting the organic EL medium is used in the photolithography patterning, and then the cathode pattern is etched by a dilute sulfuric acid to form the cathode. However, such an etching step is a problem in that the dilute sulfuric acid damages the previously formed organic EL medium layers on the substrate.

[0007] In the technology disclosed in Japanese Patent Kokai Nos. 5-275172, 5-258859 (cf. also EP-A-0 550 062) and 5-258860, such an emitting device is manufactured as follows: Straight higher walls with a height of several or tens micrometers as masks are previously formed on the substrate. The second electrodes and the organic EL medium thin films are vacuum-deposited by using such higher wall masks in such a manner that a predetermined organic EL medium vapor flow is provided in only one slanting direction to the substrate and partially and selectively shielded by the higher wall masks.

[0008] However, such a method restricts the flexible layout of pattern of pixels within a stripe shapes, since

the wall masks must be formed perpendicular to the only one slanting direction of the organic EL medium vapor flow. Therefore, it is impossibl to form a pixel pattem with a delta arrangement RGB in the panel nor any display panel with a bent or meandered cathode pattern.

[0009] Further, it is still difficult to form such higher wall masks on the substrate when fine pixels and patterns are fabricated for the full-color display panel, i.e., in detail it is very difficult to form the higher wall mask having a high aspect ratio (height/bottom) in its cross-section. Even if such higher wall masks are formed on the substrate, the strength of the wall will be low and the reliability in the performances and shapes of the resulting second electrodes and organic EL media films will be low. In addition, such a manufacture of the emitting device invites a complicated processing because of the slanting vapor flow deposition in one direction with a low precision.

SUMMARY OF THE INVENTION

[0010] Therefore, the present invention has been made to solve such a problem in view of the forgoing status. An object of the invention is to provide an organic electroluminescent display panel and method for manufacturing the same which are capable of being manufactured with a freely flexible patterning without deterioration of the organic function layer, cathode and other elements.

[0011] In accordance with a first aspect of the present invention, an organic EL display panel of the above-referenced kind is characterized in that

each electrical insulation rampart has an overhanging portion projecting in a direction parallel to the substrate preferably at an upper.

[0012] This organic EL display panel further comprises an insulative layer formed on portions of the first display electrodes to be under said overhanging portion and/or edges of the exposed portions of the first display electrodes, whereby the short-circuit between the first and the second display electrodes is prevented.

[0013] The forgoing organic EL display panel further comprises an insulative sealing film entirely formed on the first display electrode, the organic function layers and the second display electrode. At least the second display electrode is covered as a whole with the insulative sealing film, whereby the deterioration of the EL display panel is prevented.

[0014] In the forgoing organic EL display panel, said first and the second display electrodes are formed as stripes respectively, and each first display electrode is arranged perpendicular to each second display electrode.

[0015] In the forgoing organic EL display panel, the substrat and said first display lectrode ar transparent, and ach second display lectrode has a metallic luster, otherwise the organic EL display panel furth r comprises a reflectiv film formed on the second display electrode preferably.

[0016] In another embodiment of the organic EL display panel of the invention, when each of the second display electrodes is transparent, said first display electrode has a metallic luster, otherwise the organic EL display panel further comprises a reflective film formed on the first display electrode at the outer-side.

[0017] In accordance with a second aspect of the present invention, a method for manufacturing an organic EL display panel of the above-referenced kind is characterized in that the rampart formation step each of said electrical insulation ramparts is formed so as to have an overhanging portion projecting in a direction parallel to the substrate.

[0018] In this method for manufacturing an organic EL display panel, said rampart formation step further comprises preferably the steps of;

forming entirely a rampart material layer on said substrate;
forming a photo mask with a predetermined pattern openings on the rampart material layer;
etching the rampart material layer through the openings of the photo mask by using a dry-etching or wet-etching, thereby forming the ramparts having said overhanging portions.

[0019] In the forgoing method for manufacturing an organic EL display panel, the organic electroluminescent media depositing step further comprises preferably repetition of the following steps of;

putting a shadow mask onto top surfaces of the ramparts, the shadow mask having a plurality of openings corresponding to the exposed portions of the first display electrodes, while aligning the openings to the first display electrodes respectively;
depositing organic electroluminescent media through the openings onto the first display electrodes between the ramparts respectively; and
shifting the shadow mask to an adjacent portion of the top surfaces of the ramparts where the openings are aligned to adjacent other first display electrodes or layers of media, whereby enabling a high efficient manufacturing.

[0020] In this way, since the rampart protects the organic function layer during the formation thereof, there is decrease of damage of the organic function layer due to the shadow mask put thereon, even if there is performed a direct contact onto the rampart of the mask with insufficient strength and precise fine patterns such as stripe patterns. In addition, the use of the rampart and the shadow mask makes a sure separation of RGB organic function layers and shares the coatings of RGB organic m dia at a high precision.

[0021] Moreover, according to the present invention, the manufacture of the organic EL display panel further

comprises preferably;

between said patterning step for said first display electrode and said rampart formation step, forming insulative layers on portions of the first display electrodes to be under said overhanging portion and/or edges of the exposed portions of the first display electrodes, the insulative layer formed at least portions of the first display electrodes to be under said overhanging portion and/or edges of the exposed portions of the first display electrodes surely prevents the short-circuit between said first and the second display electrode.

[0022] Further, the forgoing method for manufacturing an organic EL display panel according to the present invention further comprises preferably the steps of;

after forming step of the second display electrode, forming entirely an insulative sealing film on at least of the second display electrodes, so that the insulative sealing film formed on the first display electrode, said organic function layers and said second display electrode prevents any increasing of non-emitting portions caused by the deterioration in EL media of the organic EL display panel.

[0023] Other and further features, advantages and benefits of the invention will become apparent in the following description taken in conjunction with the following drawings. It is to be understood that the foregoing general description and following detailed description are exemplary and explanatory but are not to be restrictive of the invention. The accompanying drawings which are incorporated in and constitute a part of this invention and, together with the description, serve to explain the principles of the invention in general terms. Like numerals refer to like parts throughout the disclosure.

[0024] The above set forth and other features of the invention are made more apparent in the ensuing Detailed Description of the Invention when read in conjunction with the attached Drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

Fig. 1 is a partially enlarged simplified plan view of an organic EL display panel according to the present invention;

Fig. 2 is a partially enlarged perspective view of an organic EL display panel according to the present invention;

Fig. 3 is an enlarged cross-section view of an organic EL display panel according to the present invention;

Fig. 4 is a perspective view of the substrate carrying electrodes in the organic EL display panel according to th present invention;

Figs. 5A to 5C are cross-section views showing substrates in a process for manufacturing an organic EL display panel according to the present invention;

Figs. 6A and 6B are enlarged cross-section views each showing a rampart on the substrate in a process for manufacturing an organic EL display panel according to the present invention;

Figs. 7A to 7H are enlarged cross-section views each showing a rampart on the substrate in an organic EL display panel according to the present invention;

Figs. 8A to 8D are cross-section views showing substrates in a process for manufacturing an organic EL display panel according to the present invention;

Figs. 9A to 9C are cross-section views showing substrates in a process of a first embodiment for manufacturing an organic EL display panel according to the present invention;

Fig. 10 is a scanning electron microphotograph showing a rampart on the substrate in the first embodiment of an organic EL display panel according to the present invention;

Fig. 11 is a scanning electron microphotograph showing an organic function layer and an Al electrode adjacent to a rampart on the substrate in the first embodiment of an organic EL display panel according to the present invention;

Fig. 12 is a scanning electron microphotograph showing a rampart on the substrate in a second embodiment of an organic EL display panel according to the present invention;

Fig. 13 is an enlarged cross-section view of a third embodiment of an organic EL display panel according to the present invention;

Figs. 14A to 14D are cross-section views showing substrates in a process of a fourth embodiment for manufacturing an organic EL display panel according to the present invention;

Fig. 15 is a partially enlarged plan view of the substrate in the fourth embodiment for manufacturing an organic EL display panel according to the present invention;

Fig. 16 is a cross-section view of a portion taken in line AA of Fig. 15;

Fig. 17 is a partially enlarged plan view of the substrate in the fourth embodiment for manufacturing an organic EL display panel according to the present invention;

Fig. 18 is a cross-section view of a portion taken in line AA of Fig. 17;

Fig. 19 is a partially enlarged plan view of the substrate in the fourth embodiment for manufacturing an organic EL display panel according to the present invention;

Fig. 20 is a schematic diagrams showing an ar-

rangement of th substrate and a vapor source in the fourth embodiment for manufacturing an organic EL display panel according to the present invention;

Fig. 21 is a cross-section view showing a substrat in a process of a fifth embodiment for manufacturing an organic EL display panel according to the present invention; and

Figs. 22 to 25 are enlarged cross-section views each showing a rampart and adjacent thereto on the substrate in a process of the fifth embodiment for manufacturing an organic EL display panel according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] The embodiments according to the present invention will be described in more detail with reference to the accompanying drawings.

[0027] Fig. 1 shows a partially enlarged simplified plan view of an organic EL display panel of an embodiment which is provided with a plurality of emitting pixels 1 of matrix each having emitting portions for red (R), green (G) and blue (B) lights in order to display an image. This is seen through the substrate of the panel from the outside thereof. In addition, the organic EL display panel may be formed as a monochrome display panel comprising a single color emitting portions instead of RGB emitting portions.

[0028] Fig. 2 shows a further enlarged perspective view of the backside of the panel in which the substrate 2 carries a plurality of first display electrodes or lines 3 arranged parallel to one another as stripes in a coplanar surface thereof.

[0029] Moreover, a plurality of ramparts 7 made of an electrical insulation material are formed on the substrate 2 so as to be arranged perpendicular to the first display electrode lines 3 and apart from each other, as shown in Figs. 2 and 3. The electrical insulation ramparts 7 project from or stand on the substrate 2 and expose at least portions of the first display electrodes 3 respectively.

[0030] Each electrical insulation rampart 7 has overhanging portions 7a projecting in a direction parallel to the substrate at an upper thereof. The overhanging portion 7a is formed along the extending edge of the rampart 7.

[0031] Between the ramparts 7, organic function layers 8 including at least one organic electroluminescent medium or compound are formed and arranged over the exposed portions of the first display electrodes 3. The organic function layer 8 includes three organic EL media thin films e.g., an organic hole transport layer, an organic emitting layer and an organic electron transport layer as a three-layer structure. The organic function layer 8 may alternatively include a two-layer structure comprising an organic hol transport layer and an organic emitting layer.

[0032] Second display electrodes 9 are formed on the organic function layers 8 of the organic el ctroluminescent medium respectively along the extending direction. In this way, the intersections of the first and second display electrode lines sandwiching the organic function layers correspond to light emitting portions respectively in the organic EL display panel of a simple matrix type.

[0033] On the second display electrode 9 of the panel, a protective film 10 or a protective substrate is formed preferably. In this organic EL display panel, the substrate and the first display electrodes are light transmissible, and thus the light emission radiates from the substrate. Therefore, as shown in dot lines in Fig. 3, a reflecting layer 21 may be preferably formed on the protective film 10 in order to improve the emitting efficiency. In contrast, the second display electrode may be made of a transparent material so as to emit light from the second display electrode in another embodiment of an organic EL display panel. In this case, another reflecting layer 22 may be preferably formed on the substrate 2 in order to improve the emitting efficiency.

[0034] A process for manufacturing the organic EL display panel is now described.

[0035] In a patterning step of the process, as shown in Fig. 4, a plurality of first display electrodes 3 of a stripe shape made of a transparent conductive material such as indium tin oxide (ITO) are formed parallel to each other on a transparent substrate 2 of glass by using a photolithography technology (e.g., 0.3 mm pitch, 0.28 mm width and 0.2 micrometers thickness).

[0036] Next, by using a spin-coating method in the rampart formation step, the first display electrodes 3 on the substrate 2 are entirely covered with a rampart material such as non-photosensitive polyimide 70 as a rampart layer up to a 3 micrometers thickness. Then second rampart material such as SiO_2 71 for the overhanging portion is entirely formed on the rampart layer of polyimide 70 by using a sputtering method up to a 0.5 micrometers thickness.

[0037] Next, as shown in Fig. 5A, the SiO_2 layer 71 is spin-coated with a photoresist as a mask layer up to one micrometer thickness, and then the mask 72 of photoresist each having a 20 micrometers width is formed by using an ordinary photolithography, so that the photoresist pattern for ramparts is formed.

[0038] Subsequently, as shown in Fig. 5B, the SiO_2 layer 71 is selectively etched via openings of the mask 72 by a reactive-ion etching method so as to be the same photoresist pattern of ramparts, so that the upper portions to be overhanging portions are formed. In this reactive-ion etching, the etching gas of CF_4 is mainly used at the gas flow of 100 SCCM under the conditions of a 100 W RF power for 10 minutes for the purpose of completion of the etching.

[0039] After that, as shown in Fig. 5C, the polyimide layer 70 is also selectively etched by using a dry-etching or wet-etching method, so that the body 70 of the ram-

part and overhanging portion 7a projecting in a direction parallel to the substrate at the top are form d. In this way, the rampart 7 consists of the body 70 of polyimide and the overhanging portion 71 of SiO_2 with a T-shaped cross-section as a whole. The height of the T-shaped cross-section rampart 7 from the substrate is not restricted as far as it does not provide any electric short-circuit between the individual ITO anode 3 and the individual second display electrode or cathode 9 which will be formed in the later process. Concretely, the height of the rampart 7 preferably ranges from one micrometer to 10 micrometers. In addition, the width of the overhanging portion 7a protruding from the body side of the T-shaped rampart 7 is sufficiently one micrometer or more, and the thickness of the overhanging portion is sufficiently 0.2 micrometer or more as far as they do not provide any electric short-circuit of the electrodes similarly.

[0040] This T-shaped cross-section rampart 7 is formed through the reactive-ion etching as shown in Figs. 6A and 6B in detail. First, the polyimide layer 70 is dry-etched by an O_2 gas perpendicular to the substrate without any undercut (anisotropic etching) as shown in Fig. 6A. After that, the polyimide layer 70 is wet-etched by an alkali solution for approximately 30 seconds so that the wall side 70a of the rampart body of polyimide 70 is isotropically etched as shown in Fig. 6B. Fig. 7A shows the T-shaped cross-section of the rampart 7 resulting from this two-stage etching.

[0041] Alternatively, in another etching method for engraving the polyimide layer 70, the polyimide layer 70 is isotropically wet-etched merely by an alkali solution with a pertinent concentration for 1 to 2 minutes without the previous anisotropic etching, so that SiO_2 layer 71 services as a mask for etching of the polyimide layer 70 and then undercut shapes of sidewalls of polyimide are obtained because of a isotropically wet-etching, as shown in Fig. 7B.

[0042] The so-called polyimides stated above includes a precursor which is a previous substance before imidization such as aromatic. Such a precursor is heated up to approximately 300°C after casted as shown in Fig. 5C, so that imidization is complete to cause a thermally stable polyimide. The casted aromatic precursor may be used as it is as far as it becomes integrity without any inconvenience. Alternatively, instead of polyimide and SiO_2, pertinent materials disintegrated during the first or second-stage etching may be used for the rampart body of the upper and the overhanging portion of the lower respectively. The electric insulative materials having shape strength of the rampart even before the formation of the organic function layer also may be used for them.

[0043] Figs. 7C to 7H show variations of cross-sections of the rampart instead of two-layer structure above mentioned. The reverse tapered cross-sections of the ramparts shown in Figs. 7C and 7D are formed in such a manner for example that the photoresist layer is treated with C_6H_5Cl. There may be form d the other cross-sections of the ramparts shown in Figs. 7 E to 7H as far as overhanging portions exist.

[0044] After the formation of the ramparts, the organic function layer formation step is performed as shown in Figs. 8A to 8D. The organic EL media are disposed on the exposed first display electrodes 3 respectively, so that at least one organic function layer is formed per one emitting portion. After that, in the second display electrode formation step, the second display electrodes are formed on the organic function layers. In the following figures, only one set of RGB emitting layers are shown for one pixel, but in practice a plurality of pixels are formed simultaneously in a coplanar plan of the substrate.

[0045] Fig. 8A shows in detail the organic function layer formation step. While openings 31 of the shadow mask 30 are aligned to portions of the substrate 2 each surrounded by the rampart 7 and the shadow mask is put and fixed onto top surfaces of the ramparts. After that, first organic function layers 8R for a first color emission (e.g., red) are vacuum-deposited at a predetermined thickness through the openings onto the first display electrodes 3 between the ramparts. The substrate is preferably placed during the vacuum-deposition in such a manner that the vapor of the organic EL medium goes around the overhanging portion and reaches portions under the overhanging portion. There is not restriction of angle of the substrate surface to the vapor flow. In this way, the first color organic function layers are formed on the first display electrodes respectively. In addition, in case that the organic function layer of the three-layer structure (e.g., an organic hole transport layer, an organic emitting layer and an organic electron transport layer) is formed, the corresponding different organic media may be vacuum-deposited in this step. In the later each step for the function layer, this multi-deposition may be performed similarly.

[0046] In the step of Fig. 8B, the shadow mask is shifted toward the left by one rampart so that the openings are aligned to the adjacent rampart spaces, and then the mask is fixed onto top surfaces of the ramparts. After that, second organic function layers 8G for a second color emission (e.g., green) are vacuum-deposited at a predetermined thickness onto the first display electrodes 3.

[0047] In the step of Fig. 8C, the shadow mask is similarly shifted toward the left by one rampart so that the openings are aligned to the adjacent rampart spaces, and then the mask is fixed onto top surfaces of the ramparts. After that, third organic function layers 8B for a third color emission (e.g., blue) are vacuum-deposited at the predetermined thickness onto the first display electrodes 3.

[0048] In this way, it is preferable that the mask putting and aligning step and the media depositing step are repeated in such a manner of that the shadow mask is shifted to an adjacent portion where the openings aligned to adjacent other first display electrodes, since

the manufacturing of the panel is improved conveniently. The rampart 7 is useful to prevent the shadow mask from damaging the organic function layer when th aligning, shifting and putting of the mask are performed in the vacuum-depositions of the organic function layers.

[0049] Fig. 8D shows a step for forming the second display electrodes 9 in which, after the shadow mask for the organic function layers are removed, a low resistance metal such as Al, Mg, Au and the like and an alloy thereof is vacuum-deposited as cathodes 9 with a predetermined thickness on the resulting RGB organic function layers 8 in such a manner that the metal vapor drops perpendicular to the substrate without step coverage. It is noted that the metal vapor flow is substantially vertical to the surface of the substrate so that the overhanging portion 7a of the rampart prevents the deposition of the metal thereunder on the edges of the organic function layer or at least, lower face of the overhanging portion per se.

[0050] The overhanging portion 7a of the rampart divides the metal layer deposited by the vertical metal vapor flow to the substrate, so that the cathode 9 is formed physically electrically apart from the metal layer deposited on the top face of the rampart as shown in Fig. 8D. Therefore, the adjacent cathodes 9 sandwiching the rampart are electrically disconnected to each other. Moreover, the combination of the vertical metal vapor flow and the overhanging portion also causes the electrical insulation between the cathode 9 and the ITO anode 3 to prevent a short circuit therebetween, since the metal vapor flow going around the overhanging portion 7a does not reach so far as the edge of the organic function layer 8 of the organic EL medium previously formed so that the organic function layer 8 appears from the cathode 9 as shown in Fig. 8D. Thickness of the metal cathode is not restricted as far as it does not provide any short circuit. For the metal cathode a low resistance metal such as Al, Mg, Cu, Au and the like and an alloy thereof is used.

[0051] Next, Figs. 9A to 9C show another embodiment process for an organic EL display panel carrying ramparts of reverse tapered cross-section.

[0052] As shown in Fig. 9A, the ramparts 7 each having the reverse tapered cross-section are formed on the substrate 2 on which the ITO anode 3 with a predetermined pattern previously formed in a way that a site 9a to be an edge of the cathode takes shelter from the metal vapor flow vertically dropped later by means of overhanging portion 7a.

[0053] As shown in Fig. 9B, by using the shadow mask 30 the RGB organic function layers are formed in turn on the substrate 2 in the same manner mentioned above. Since the shadow mask contacts via the rampart servicing as a spacer to the organic EL medium during the vacuum-deposition, the mask can not damage the organic function layer due to a gap between the shadow mask and the ITO anode or the organic function layer maintained by the rampart. In addition, this vacuum-deposition is performed while th substrate is rotated with respect to an axis extending normally to the surface thereof in order that the EL medium goes around the overhang of the reverse tapered rampart and reaches the base thereof. Instead of the rotation of the substrate, a plurality of vapor sources may be used for entering the EL medium to the root of the reverse tapered rampart from various directions based on the sources. The deposition of EL medium at the root of the rampart is efficient for the wide spread organic function layer preventing s short-circuit between the ITO anode and the cathode formed later.

[0054] As shown in Fig. 9C, the cathode material of metal is vacuum-deposited perpendicular to the surface of the substrate. As seen from the figure, the overhanging portion 7a of the reverse tapered rampart interrupts the metal vapor flow from the root adjacent to the site 9a to be a cathode edge. In this way, both the electrical separations of the adjacent cathodes between which the rampart is put and of the ITO anode and the cathode pattern are simultaneously achieved.

[0055] Last, after the sealing against moisture is performed, an organic EL full-color display panel is obtained.

[0056] Of course, the organic EL full-color display panel may be formed as a monochrome display panel by depositing single color organic function layers are deposited, instead of RGB organic function layers of the steps as shown in Fig. 9B and Fig. 8A to 8C. In addition, another EL full-color display panel may be obtained when RGB filters are provided and white color organic function layers are formed on the substrate.

[0057] The organic EL display panel according to the present invention does not lose its inherent performance for a long period, since there is no process with probability of damaging the organic function layer such as the wet type photolithography after the formation step of the organic EL layers. In addition, since the cathode is formed with the vertical metal flow, the flexible cathode pattern may be obtained. Further, the reverse tapered rampart may be formed by the photolithography at a fine patterning with a precision of 10 micrometers or less.

[0058] The feature of the present invention of the organic EL display panel is the existence of ramparts on the substrate each comprising the overhanging portion and having a T-shaped cross-section or the reverse tapered cross-section at the portion or the whole thereof. The feature of the method according to the present invention is that the organic EL medium material vapor flow goes around the overhanging portion closer to the base of the reverse tapered or T-shaped rampart than the cathode metal material vapor flow.

(EXAMPLE 1)

[0059] An organic EL display panel was fabricated in that the rampart on the substrate was made of a pho-

toresist of chemically amplified type.

[0060] ITO anodes were patterned in the stripe form on a glass substrate, and then the substrate was sufficiently washed. The nega-photoresist LAX-1 (available from Nippon Zeon Co. ltd.) was spin-coated at a thickness of 5.6 micrometers as a layer on the substrate. Then, the coated substrate was pre-baked in a warm air current circulatory oven. After that, a photo mask providing parallel slits for cathodes each width of 20 micrometers was put on the photoresist layer in a manner that the slits extends perpendicular to the ITO stripes. Then, the photoresist layer was exposed with a pertinent radiation through the slits of the photo mask. Subsequently, the photoresist layer was performed with P.E.B in the warm air current circulatory oven and was developed, so that reverse tapered ramparts each having a width of 20 micrometers and a height of approximately 5.6 micrometers were formed (see Fig. 10 showing a scanning electron microphotograph of the rampart).

[0061] After a shadow mask provided with openings each corresponding to a recess between ramparts was put on the ramparts, N, N' -diphenyl-N-N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine (so-called "TPD") was vacuum-deposited at a 700 angstroms thickness through the openings onto the surface carrying the ramparts while the substrate is rotated with respect to an axis extending normally to the surface thereof. in order that the EL medium goes around the overhang of the reverse tapered rampart and reaches the base thereof. Subsequently, Aluminum oxine chelate (hereinafter referred as "Alq_3") was vacuum-deposited at a 550 angstroms thickness in the same manner. After the depositions, the substrate was stopped to rotate. Aluminum was vacuum-deposited at a 1000 angstroms as cathodes in a manner that Al vapor flow is perpendicular to the substrate (see Fig. 11 of a scanning electron microphotograph showing portins adjacent to the rampart).

[0062] As seen from Fig. 11, the Al layer on the top of the rampart is divided from that of on the substrate at the edge of the Al cathode layer on the substrate near the base of the rampart, so that the adjacent Al cathode lines formed on the substrate are electrically disconnected to one another. In addition, the edge of the organic function layer comprising TPD and Alq_3 sticks out from the edge of the Al cathode layer, so that any short-circuit between the Al cathode and the ITO anode does not occur.

(EXAMPLE 2)

[0063] Another organic EL display panel was fabricated in that the rampart of a photoresist on the substrate was treated with C_6H_5Cl.

[0064] ITO anodes were patterned in the stripe form on a glass substrate, and then the substrate was sufficiently washed. The posi-photoresist AZ6112 (available from Hoechst Japan Ltd.) was spin-coated at a thickness of approximately one micrometer as a layer on the substrate. Then, th coated substrate was pre-baked in a warm air current circulatory oven. After that, the coated substrate was dipped into a C_6H_5Cl fluid at a temperature of 32°C for 30 minutes. Then, a photo mask providing parallel slits for cathodes each width of 2 micrometers was put on the photoresist layer in a manner that the slits extends perpendicular to the ITO stripes. Then, the photoresist layer was exposed with a pertinent radiation through the slits of the photo mask. Subsequently, the photoresist layer was developed, so that reverse tapered ramparts each having a width of 2 micrometers and a height of approximately one micrometer were formed (see Fig. 12 showing a scanning electron microphotograph of the rampart).

[0065] Next, an organic function layer comprising TPD and Alq_3 and an Al cathode layer were formed in the same manner that of EXAMPLE 1.

[0066] As a result, the Al layer on the top of the rampart was divided from that of on the substrate at the edge of the Al cathode layer on the substrate near the base of the rampart, so that the adjacent Al cathode lines formed on the substrate were electrically disconnected to one another. In addition, the edge of the organic function layer comprising TPD and Alq_3 sticked out from the edge of the Al cathode layer, so that any short-circuit between the Al cathode and the ITO anode did not occur.

[0067] According to the present invention, it makes sure of automatically completely patterning of the cathode lines without use of the photolithography for the cathode patterning, since the Al layer on the top of the rampart with overhanging portions is electrically separated from that of on the substrate during the vacuum deposition. In addition, the film formation of the organic function layer with using the rampart and the shadow mask put thereto realizes an available separation of the organic function layers, so that a colorful fine full color display panel comprising organic function layers is manufactured without deterioration of the organic function layer nor any leakage of EL medium to adjacent pixels. The number of the steps in the manufacturing is therefore reduced than those of the prior art, the separation of the RGB organic function layers is surely achieved so that the RGB media are shared with a high precision.

(EXAMPLE 3)

[0068] Another full color display panel in which nonlinear elements each including thin film transistors (TFT) and capacitors connected to the second display electrodes is fabricated together with scan signal lines and data signal lines on the substrate as shown in Fig. 13. As seen from the figure, ITO anode layers 3, organic function layers 8 and second display electrodes 9 are previously formed on a glass substrate 2 as a front substrate in the same manner as the forgoing embodiments. Individually, a back glass substrate 102 carrying nonlinear elements 101 connected to the second dis-

play electrodes 9 and the scan data signal lines are formed correspondingly to the number of predetermined pixels. Thus, an anisotropic conductive adhesiv 103 adheres both the front and back substrates so that the nonlinear elements 101 are electrically connected only to the corresponding second display electrodes 9 respectively to result in a flat display panel.

[0069] In the formation of the TFT EL flat display panel, it should be noted that individual cathode and organic function layer precisely corresponds separately to each emitting portion of the pixel, and further one of the cathode is perfectly insulative electrically to the adjacent cathode. This requirement is achieved by another embodiment of the present invention that the T-shaped cross-section or reverse tapered ramparts with overhanging portion are formed in the form of a two dimension matrix.

[0070] In addition, the present invention realizes an organic electroluminescent display panel and method for manufacturing the same which are capable not only of being manufactured with a freely flexible patterning without deterioration of the organic function layer, cathode and other elements, but also of preventing any puncture of the first and second display electrodes and the organic function layer with a high yield rate in the production thereof. Namely, in Example 4, at least one insulative layer is inserted between the first and second display electrodes under the overhanging portion of the rampart. In Example 5, the ramparts and the second display electrodes are covered with an insulative sealing film.

(EXAMPLE 4) Addition of an insulative layer

[0071] There are manufactured an organic EL display panel including insulative layers preventing the short-circuit between the first and the second display electrodes, particularly at the edge of the second display electrode.

[0072] As shown in Fig. 14A, after the first display electrodes 3 (ITO anodes) are previously formed in the predetermined pattern on the substrate, insulative layers 40 are formed on the sites planed to be at edges of the second display electrodes formed later.

[0073] As shown in Fig. 14B, the ramparts 7 each having the reverse tapered cross-section are formed on the insulative layers 40 and the substrate 2 in a way that each overhanging portion 7a of the ramparts 7 covers the insulative layer at the site planed to be at edges of the second display electrodes formed later. The insulative layers 40 are formed on gaps between the second display electrodes or patterns to define the shape of the second display electrode.

[0074] As shown in Fig. 14C, by using the shadow mask 30 with the predetermined openings, the RGB organic function layers are formed in turn on the rotating substrate 2 in the same manner mentioned above. The shadow mask is contact d to th ramparts apart from the organic function layers during the vacuum-deposition. The mask thus did not damage the organic function layer.

[0075] As shown in Fig. 14D, the cathode metal material is vacuum-deposited as a whole to the surface of the substrate. This vacuum-deposition is performed by the angle θ less than a tapering angle θ' ($\theta < \theta'$) of the reverse tapered rampart with respect an axis extending normally to the substrate. The overhanging portion 7a of the reverse tapered rampart interrupted the metal vapor flow from the root adjacent to the site to be a cathode edge, so that there are simultaneously achieved both the electrical separations of the adjacent cathodes between which the rampart is placed and of the ITO anode and the cathode. In addition, There is no short-circuit between the edges of the cathode i.e., the second display electrode and the previously formed ITO anode even when the deposited metal cathode crosses over the edge of the organic function layer because of the insulative layer 7 formed in the step of Fig. 14A.

[0076] Last, after the sealing against moisture is performed, an organic EL full-color display panel is obtained.

[0077] A monochrome EL display panel may be obtained if deposition of single color organic function layers are deposited, instead of RGB organic function layers of the steps as shown in Fig. 14C. In addition, another EL full-color display panel may be obtained when RGB filters are provided and white color organic function layers are formed on the substrate.

[0078] The area range of each insulative layer formed in the step of Fig. 14A is at least each edge portion (Fig. 15) of the adjacent second display electrodes and further at maxim the surface of the substrate other than emitting portion of displaying dots (segments) (see Fig. 19). For example, Fig. 15 shows the pattern of the insulative layers 40 in the insulative layer formation step of Fig. 14A in which a pair of the parallel insulative layer stripes 40a and 40b extending vertical to the first display electrode 3. In this case, these parallel insulative layer stripes 40a and 40b are formed as sandwiching the base of the rampart 7 as shown in Fig. 16. In anther embodiment, the integrated insulative layers 40 may be formed so as to combine those parallel insulative stripes of Fig. 15 extending vertical to the first display electrode 3 as shown in Fig. 17. In this case, the ramparts 7 are formed along the center line of each integrated insulative layer 40 as shown in Fig. 18. In further anther embodiment, the insulative layer may be formed so as to combine those vertical and lateral insulative stripes as shown in Fig. 19. That is, the insulative layer is formed on the surface of the substrate other than the exposed portions 50 of the first display electrode and the edge portions 60 of the first display electrodes. As a result, the insulative layer also prevents the short-circuit between the edge of the first display electrode and the second display electrode.

[0079] The organic EL display panel according to this

embodiment maintains its inher nt performance for a long period after the production, therefore a high yield rate of the production, since there is no process with probability of damaging the organic function layer such as the wet type photolithography after the formation step of the organic EL layers. In addition, since the direction of the deposition of the second display electrode is free, a variety of second display electrode patterns are achieved. In addition, the insulative layer placed between the edge of the second display electrode and the first display electrode prevents the short-circuit therebetween. Moreover, the reverse tapered rampart and the insulative layer may be formed by the photolithography at a fine patterning with a precision of 10 micrometers or less.

[0080] Concretely, an organic EL display panel including the insulative layer placed between the edge of the second display electrode and the first display electrode was manufactured in substantially the same manner as Example 1 above mentioned, in which the insulative layer formation step was inserted between the first display electrode step and the rampart formation step.

[0081] ITO anodes were patterned in the stripe form on a glass substrate, and then the substrate was sufficiently washed. The photoresist OFPR-8000 (available from Tokyo Ohka Co. ltd.) was spin-coated at a thickness of one micrometer as an insulative layer on the substrate. Then, the coated substrate with the insulative layer was prebaked in the warm air current circulatory oven. After that, a photo mask providing parallel slits for cathodes each width of 20 micrometers was put on the photoresist insulative layer in a manner that the slits extends perpendicular to the ITO stripes. Then, the photoresist layer was exposed with a pertinent radiation through the slits of the photo mask. Subsequently, the photoresist layer was developed and rinsed and then post-baked in the warm air current circulatory oven. In this way, the stripe insulative layer 40 as shown in Fig. 17 were formed.

[0082] Next, the nega-photoresist LAX-1 (available from Nippon Zeon Co. ltd.) was spin-coated at a thickness of 5.6 micrometers as a layer on the substrate. Then, the coated substrate was pre-baked in a warm air current circulatory oven. After that, a photo mask providing parallel slits for cathodes each width of 18 micrometers was put on the photoresist layer in a manner that both the center lines of each insulative layer and each stripe slit of the photo mask (the line width 18 micrometers) are coincides with each other. Then, the photoresist layer was exposed with a pertinent radiation through the slits of the photo mask. Subsequently, the photoresist layer was performed with P.E.B in the warm air current circulatory oven and was developed, so that reverse tapered ramparts each having a width of 18 micrometers and a height of approximately 5.6 micrometers were formed. The tapering angle θ' of the reverse tapered rampart in respect to the normal line of the substrate was measured to b approximately 30 degree.

[0083] Next, the substrate 2 was fixed to the turntable provided in the vacuum chamber of the vacuum deposition device in the form shown in Fig. 20, and then the vacuum chamber was exhausted up to a pressure of -5 x 10^{-6} Torr and then the vacuum deposition was performed with a resistance heating method while the substrate was rotated with respect to an axis extending normally to the surface thereof. Under this condition TPD was vacuum-deposited at a 700 angstroms thickness. Subsequently, Alq_3 was vacuum-deposited at a 550 angstroms thickness in the same manner. Further, the second display electrode of Al was vacuum-deposited at a 1000 angstroms thickness. In these cases each of the material vapor sources 55 corresponding the steps was placed under the substrate 2 and therefore the vapor flow biased by the angle θ = 20 degree at maxim from the normal line of the substrate less than tapering angle θ' = 30 degree the reverse tapered rampart. There was no measured the conductivity cross the adjacent Al lines between which the rampart exists so that a perfect electrical insulation was complete. In addition, upon application of 10 Volts across the ITO and Al electrodes of the resultant display panel, the selected organic function layers emitted a green light at a high luminance but not occurs any short-circuit therebetween.

(EXAMPLE 5) Addition of an insulative sealing film

[0084] An insulative sealing film is formed as surrounding the reverse tapered rampart and covering entirely the second display electrode pattern. A substrate carrying the second display electrodes is previously formed through the steps shown in Figs. 14A to 14D in the same manner of Example 4. The substrate is covered with an insulative sealing film 45 with a high damp-proof effect by using the vacuum deposition while the substrate is rotated, sputtering or CVD method.

[0085] The insulative sealing film is deposited in such a manner that the sealing material vapor goes around the over hanging portion toward the tapered side walls and the base of the reverse tapered rampart 7 as shown in Fig. 21. Therefore, the sealing material vapor reaches at the insulative layer 40 as shown in Fig. 22, so that the second display electrode lines 9 are perfectly covered the insulative sealing film 45. In addition, the insulative sealing film 45 may cover the tapered side walls of the reverse tapered rampart 7 as shown in Fig. 23. As far as the insulative layer 40 covers at least the second display electrode lines, the form thereof is not restricted.

[0086] Moreover, this sealing structure may be applied to the above mentioned Examples as well as Example 4 in which no insulative layer is formed in the panel. As shown in Fig. 24, the insulative sealing film is deposited in such a manner that the sealing material vapor goes around the over hanging portion toward the base of the reverse tapered rampart 7, so that the edges of the second display electrode 9 and the organic function layer 8 and the surface portion of the first display elec-

trode 3 on the substrate are covered with the insulative sealing film 45. Alternatively, as shown in Fig. 25, all of the second display electrode lines 9, th reverse tapered rampart 7 including the tapered side walls and the lik may be perfectly covered the insulative sealing film 45.

[0087] The present invention prevents non-emitting portions or dark spots growing or entering from the edge of the second display electrode to the organic function layer, since the insulative sealing film for perfectly covering the second display electrode pattern. In other words, the organic EL display panel according to the present invention has a very high durability.

[0088] Concretely, an organic EL display panel including the insulative layer and the insulative sealing film was manufactured in substantially the same manner as Example 4 above mentioned, in which the insulative sealing film formation step was added after the second display electrode formation step.

[0089] A substrate carrying the Al display electrodes was previously formed through steps in the same manner as Example 4. After that, by using the sputtering method, a SiO_2 layer was deposited as an insulative sealing film at a one micrometer thickness. There was no measured any conductivity between the adjacent Al lines between which the rampart exists so that a perfect electrical insulation was complete. In addition, upon application of 10 Volts across the ITO and Al electrodes of the resultant display panel, the selected organic function layers emitted a green light at a high luminance but not occurs any short-circuit therebetween. Furthermore, the resultant display panel did not have non- emitting portions in the organic function layer nor expansion thereof for a long period of several days in the air.

[0090] According to the present invention, the following advantageous effects are obtained.

(1) After the formation of the organic EL layers, it is unnecessary to perform a step with probability of damaging the organic function layer such as the photolithography. Due to existence of the ramparts, the protection of the organic function layer is stable and the damage of the layers is reduced.

(2) The number of the steps in the manufacturing is reduced than those of the prior art, the separation of the RGB organic function layers is surely achieved so that the RGB media are shared with a high precision.

(3) A freely flexible patterning on the substrate is realized without deterioration of the organic function layer, cathode and other elements.

[0091] It should thus be apparent that the scope of the teaching of this invention is not intended to be limited by only the embodim nts that have been expressly disclosed and illustrated, but that instead th scope of the teaching of this invention should be read as being commensurate with the scope of the claims that follow.

Claims

1. An organic electroluminescent display panel having a plurality of emitting portions comprising:

   a substrate on which a plurality of first display electrodes corresponding to emitting portions are formed;

   electrical insulation ramparts projecting from the substrate for exposing at least portions of the first display electrodes respectively;

   organic function layers each including at least one organic electroluminescent medium formed on exposed portions of the first display electrodes; and

   second display electrodes formed on the organic function layers;

   characterized in that
   each electrical insulation rampart has an overhanging portion projecting in a direction parallel to the substrate.

2. An organic electroluminescent display panel as set forth in claim 1 and further comprising: an insulative layer formed on portions of the first display electrodes to be under said overhanging portion and/or edges of the exposed portions of the first display electrodes.

3. An organic electroluminescent display panel as set forth in claim 1 and further comprising:
   an insulative sealing film entirely formed on the first display electrode, the organic function layers and the second display electrode; and at least the second display electrode being covered as a whole with the insulative sealing film.

4. An organic electroluminescent display panel as set forth in claim 1 and further comprising:
   an insulative sealing film entirely formed on the first display electrode, the organic function layers and the second display electrode; and at least the organic function layers being covered as a whole with the insulative sealing film.

5. An organic electroluminescent display panel as set forth in claim 1, wherein said first and the second display electrodes are formed as stripes respectively, and each first display electrode is arranged perpendicular to each second display electrode.

6. An organic electroluminescent display panel as set forth in claim 1, wherein said substrate and said first display lectrode are transpar nt.

7. An organic electroluminescent display panel as set forth in claim 6 and further comprising:
a reflective film formed on said second display el c-trode.

8. An organic electroluminescent display panel as set forth in claim 1, wherein said second display electrode is transparent.

9. An organic electroluminescent display panel as set forth in claim 8 and further comprising a reflective film formed on the first display electrode at the outer-side.

10. A method for manufacturing an organic electroluminescent display panel having a plurality of emitting portions comprising the steps of:

forming a plurality of first display electrodes corresponding to emitting portions on a substrate as a patterning step;

forming, on the substrate, electrically insulative ramparts for exposing at least portions of the first display electrodes and protruding from the substrate as a rampart formation step;

depositing organic electroluminescent media onto exposed portions of the first display electrodes respectively as an organic electroluminescent media depositing step, thereby forming a plurality of organic function layers each including at least one organic electroluminescent medium on the first display electrodes; and

forming a plurality of second display electrodes formed on the organic function layers as a forming step of the second display electrode,

characterized in that
in the rampart formation step each of said electrical insulation ramparts is formed so as to have an overhanging portion projecting in a direction parallel to the substrate.

11. A method as set forth in claim 10,

wherein said rampart formation step comprises the steps of:

forming entirely a rampart material layer on said substrate;

forming a resist mask with a predetermined pattern openings on the rampart material layer; and

etching the rampart material layer through the openings of the resist mask by using a dry-etching or wet-etching, thereby forming the ramparts having said overhanging portions.

12. A method as set forth in claim 10 or 11,

wherein the organic electroluminescent media depositing step comprises repetition of the following steps of:

putting a shadow mask onto top surfaces of the ramparts, the shadow mask having a plurality of openings corresponding to the portions of the first display electrodes to be exposed, while aligning the openings to the first display electrodes respectively;

depositing organic electroluminescent media through the openings onto the first display electrodes or layers of media between the ramparts respectively; and

shifting the shadow mask to an adjacent portion of the top surfaces of the ramparts where the openings are aligned to adjacent other first display electrodes or layers of media.

13. A method as set forth in anyone of claims 10 to 12, and further comprising:

between said patterning step for said first display electrode and said rampart formation step,

forming insulative layers on portions of the first display electrodes to be under said overhanging portion and/or edges of the exposed portions of the first display electrodes.

14. A method as set forth in anyone of claims 10 to 13 and further comprising:

after the forming step of the second display electrode,
forming entirely an insulative sealing film on at least the whole of the second display electrodes, so that the insulative sealing film is formed on the first display electrode.

Patentansprüche

1. Organisches Elektrolumineszenzanzeigefeld mit einer Vielzahl von emittierenden Abschnitten, umfassend:

ein Substrat, auf dem eine Vielzahl von ersten Anzeigeelektroden gemäß emittierenden Abschnitten gebildet ist,

elektrische Isolationswälle, die von dem Substrat vorstehen, um jeweils mindestens Abschnitte der ersten Anzeigeelektroden freizulegen,

organische Funktionsschichten, die jeweils mindestens ein organisches Elektrolumineszenzmedium umfassen, das auf freigelegten Abschnitten der ersten Anzeigeelektroden gebildet ist, und

zweite Anzeigeelektroden, die auf den organischen Funktionsschichten gebildet sind,

dadurch gekennzeichnet, daß
jeder elektrische Isolationswall einen überhängenden Abschnitt aufweist, der in einer Richtung parallel zum Substrat vorsteht.

2. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 1 und ferner umfassend:
eine isolierende Schicht, die auf Abschnitten der ersten Anzeigeelektroden gebildet ist, so daß sie sich unter dem überhängenden Abschnitt und/oder Rändern der freigelegten Abschnitte der ersten Anzeigeelektroden befindet.

3. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 1 und ferner umfassend:
einen isolierenden Versiegelungsfilm, der vollständig auf der ersten Anzeigeelektrode, den organischen Funktionsschichten und der zweiten Anzeigeelektrode gebildet ist, und wobei zumindest die zweite Anzeigeelektrode als Ganzes mit dem isolierenden Versiegelungsfilm bedeckt ist.

4. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 1 und ferner umfassend:
einen isolierenden Versiegelungsfilm, der vollständig auf der ersten Anzeigeelektrode, den organischen Funktionsschichten und der zweiten Anzeigeelektrode gebildet ist, und wobei zumindest die organischen Funktionsschichten als Ganzes mit dem isolierenden Versiegelungsfilm bedeckt sind.

5. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 1, wobei die ersten und die zweiten Anzeigeelektroden jeweils als Streifen gebildet sind und jede erste Anzeigeelektrode rechtwinklig zu jeder zweiten Anzeigeelektrode angeordnet ist.

6. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 1, wobei das Substrat und die erste Anzeigeelektrode transparent sind.

7. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 6 und ferner umfassend:
einen reflektier nden Film, der auf der zweiten Anzeigeelektrode gebildet ist.

8. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 1, wobei die zweite Anzeigeelektrode transparent ist.

9. Organisches Elektrolumineszenzanzeigefeld nach Anspruch 8 und ferner einen reflektierenden Film umfassend, der auf der ersten Anzeigeelektrode an der Außenseite gebildet ist.

10. Verfahren zum Herstellen eines organischen Elektrolumineszenzanzeigefeldes mit einer Vielzahl von emittierenden Abschnitten mit den Schritten, daß:

als ein Musterungsschritt eine Vielzahl von ersten Anzeigeelektroden gemäß emittierenden Abschnitten auf einem Substrat gebildet wird,

als ein Wallbildungsschritt auf dem Substrat elektrisch isolierende Wälle gebildet werden, die von dem Substrat vorstehen, um zumindest Abschnitte der ersten Anzeigeelektroden freizulegen, und

als ein Schritt zum Abscheiden organischer Elektrolumineszenzmedien organische Elektrolumineszenzmedien jeweils auf freigelegte Abschnitten der ersten Anzeigeelektroden abgeschieden werden, wodurch eine Vielzahl von organischen Funktionsschichten, die jeweils zumindest ein organisches Elektrolumineszenzmedium umfassen, auf den ersten Anzeigeelektroden gebildet wird, und

als ein Schritt zum Bilden der zweiten Anzeigeelektrode eine Vielzahl von zweiten Anzeigeelektroden gebildet wird, die auf den organischen Funktionsschichten gebildet werden,

dadurch gekennzeichnet, daß
bei dem Wallbildungsschritt jeder der elektrischen Isolationswälle derart gebildet wird, daß er einen überhängenden Abschnitt aufweist, der in einer Richtung parallel zum Substrat vorsteht.

11. Verfahren nach Anspruch 10,

wobei der Wallbildungsschritt die Schritte umfaßt, daß:

eine Wallmaterialschicht vollständig auf dem Substrat gebildet wird,

ein Resistmaske mit vorbestimmten Musteröffnungen auf der Wallmaterialschicht gebildet wird, und

die Wallmaterialschicht durch die Öffnungen der Resistmaske hindurch unt r Verwendung von Trockenätzen oder Naßätzen geätzt wird, wodurch die Wälle mit den überhängenden Abschnitten gebildet werden.

12. Verfahren nach Anspruch 10 oder 11,

wobei der Schritt zum Abscheiden organischer Elektrolumineszenzmedien die Wiederholung der folgenden Schritte umfaßt, daß:

eine Schattenmaske auf obere Oberflächen der Wälle gesetzt wird, wobei die Schattenmaske eine Vielzahl von Öffnungen gemäß den freizulegenden Abschnitten der ersten Anzeigeelektroden aufweist, während die Öffnungen jeweils mit den ersten Anzeigeelektroden ausgerichtet werden,

organische Elektrolumineszenzmedien durch die Öffnungen hindurch jeweils auf die ersten Anzeigeelektroden oder Medienschichten zwischen den Wällen abgeschieden werden, und

die Schattenmaske zu einem benachbarten Abschnitt der oberen Oberflächen der Wälle verschoben wird, bei dem die Öffnungen mit benachbarten weiteren ersten Anzeigeelektroden oder Medienschichten ausgerichtet werden.

13. Verfahren nach irgendeinem der Ansprüche 10 bis 12, das ferner umfaßt, daß :

zwischen dem Musterungsschritt für die erste Anzeigeelektrode und dem Wallbildungsschritt

isolierende Schichten auf Abschnitten der ersten Anzeigeelektroden gebildet werden, so daß sie sich unter dem überhängenden Abschnitt und/oder Rändern der freigelegten Abschnitte der ersten Anzeigeelektroden befinden.

14. Verfahren nach irgendeinem der Ansprüche 10 bis 13, das ferner umfaßt, daß

nach dem Schritt zum Bilden der zweiten Anzeigeelektrode

ein isolierender Versiegelungsfilm vollständig auf zumindest den gesamten zweiten Anzeigeelektroden gebildet wird, so daß der isolierende Versiegelungsfilm auf der ersten Anzeigeelektrode gebildet wird.

Revendi atl n

1. Panneau d'affichage électroluminescent organique comportant une pluralité de parties émettrices comprenant :

un substrat sur lequel est formée une pluralité de premières électrodes d'affichage correspondant à des parties émettrices;
des remparts d'isolation électrique faisant saillie depuis le substrat pour exposer respectivement au moins des parties des premières électrodes d'affichage;
des couches de fonction organiques comprenant chacune un milieu électroluminescent organique formé sur des parties exposées des premières électrodes d'affichage; et
des deuxièmes électrodes d'affichage formées sur les couches de fonction organiques;

caractérisé en ce que
chaque rempart d'isolation électrique comporte une partie en surplomb qui fait saillie dans une direction parallèle au substrat.

2. Panneau d'affichage électroluminescent organique selon la revendication 1, et comprenant de plus :
une couche isolante formée sur des parties des premières électrodes d'affichage qui doivent être sous ladite partie en surplomb et/ou des bords des parties exposées des premières électrodes d'affichage.

3. Panneau d'affichage électroluminescent organique selon la revendication 1, et comprenant de plus :
un film de scellement isolant entièrement formé sur les premières électrodes d'affichage, les couches de fonction organiques et les deuxièmes électrodes d'affichage; et au moins les deuxièmes électrodes d'affichage étant recouvertes dans leur ensemble par le film de scellement isolant.

4. Panneau d'affichage électroluminescent organique selon la revendication 1, et comprenant de plus :
un film de scellement isolant entièrement formé sur les premières électrodes d'affichage, les couches de fonction organiques et les deuxièmes électrodes d'affichage; et au moins les couches de fonction organiques étant recouvertes dans leur ensemble par le film de scellement isolant.

5. Panneau d'affichage électroluminescent organique selon la revendication 1, dans lequel lesdites premières et deuxièmes électrodes d'affichage sont réalisées respectivement sous forme de bandes, et chaque première électrode d'affichage est agencée perpendiculairement à chaque deuxième électrode d'affichage.

6. Panneau d'affichag électroluminescent organique selon la revendication 1, dans lequel ledit substrat et lesdites premières électrodes d'affichage sont transparents.

7. Panneau d'affichage électroluminescent organique selon la revendication 6, et comprenant de plus :

un film réflecteur formé sur lesdites deuxièmes électrodes d'affichage.

8. Panneau d'affichage électroluminescent organique selon la revendication 1, dans lequel lesdites deuxièmes électrodes d'affichage sont transparentes.

9. Panneau d'affichage électroluminescent organique selon la revendication 8, et comprenant de plus un film réflecteur formé sur les premières électrodes d'affichage sur le côté extérieur.

10. Procédé de fabrication d'un panneau d'affichage électroluminescent organique comportant une pluralité de parties émettrices, comprenant les étapes consistant à :

former une pluralité de premières électrodes d'affichage correspondant à des parties émettrices, comme étape de formation des motifs;
former, sur le substrat, des remparts d'isolation électrique pour exposer au moins des parties des premières électrodes d'affichage et faisant saillie depuis le substrat, comme étape de formation de remparts;
déposer des milieux électroluminescents organiques sur des parties exposées des premières électrodes d'affichage respectivement, comme étape de dépôt de milieux électroluminescents organiques, pour former de ce fait une pluralité de couches de fonction organiques comprenant chacune au moins un milieu électroluminescent organique sur les premières électrodes d'affichage; et
former une pluralité de deuxièmes électrodes d'affichage formées sur les couches de fonction organiques, comme étape de formation de deuxièmes électrodes d'affichage,

caractérisé en ce que dans l'étape de formation de remparts, chacun desdits remparts d'isolation électrique est formé de façon à comporter une partie en surplomb qui fait saillie dans une direction parallèle au substrat.

11. Procédé selon la revendication 10, dans lequel ladite étape de formation de r mparts comprend les étapes consistant à :

former entièrement une couche de matériau de r mpart sur ledit substrat;
former un masque de résist avec un motif prédéterminé débouchant sur la couche de matériau de rempart; et
attaquer la couche de matériau de rempart à travers les ouvertures du masque de résist en utilisant un procédé d'attaque à sec ou d'attaque par réactif liquide, pour former de ce fait les remparts comportant lesdites parties en surplomb.

12. Procédé selon la revendication 10 ou 11, dans lequel l'étape de dépôt de milieux électroluminescents organiques comprend la répétition des étapes suivantes consistant à :

poser un masque perforé sur les surfaces de sommet des remparts, le masque perforé comportant une pluralité d'ouvertures correspondant aux parties des premières électrodes d'affichage à exposer, tout en alignant les ouvertures respectivement sur les premières électrodes d'affichage;
déposer des milieux électroluminescents organiques à travers les ouvertures sur les premières électrodes d'affichage ou couches de milieux entre les remparts respectivement; et
déplacer le masque perforé jusqu'à une partie adjacente des surfaces de sommet des remparts où les ouvertures sont alignées avec d'autres premières électrodes d'affichage ou couches de milieux adjacentes.

13. Procédé selon l'une quelconque des revendications 10 à 12, comprenant en outre :

entre ladite étape de formation des motifs pour lesdites premières électrodes d'affichage et ladite étape de formation de remparts,
le fait de former des couches isolantes sur des parties des premières électrodes d'affichage devant être sous ladite partie en surplomb et/ou des bords des parties exposées des premières électrodes d'affichage.

14. Procédé selon l'une quelconque des revendications 10 à 13, comprenant en outre :

après l'étape de formation des deuxièmes électrodes d'affichage,
le fait de former entièrement un film de scellement isolant sur au moins la totalité des deuxièmes électrodes d'affichage, de sorte que le film de scellement isolant est formé sur les premières électrodes d'affichage.

FIG. 1

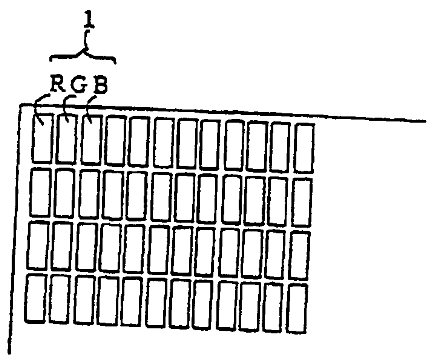


FIG. 2

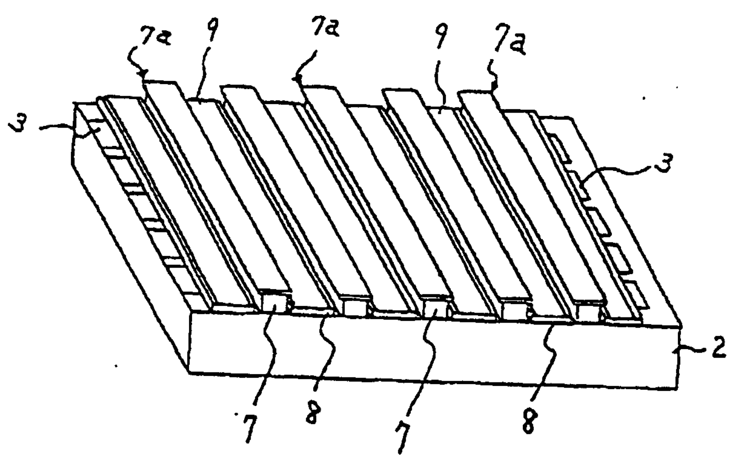


FIG. 3

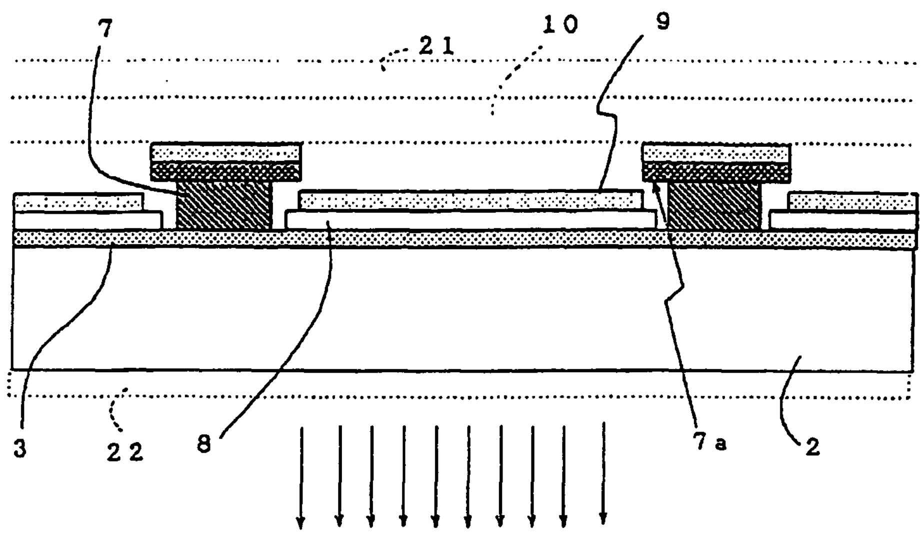


FIG. 4

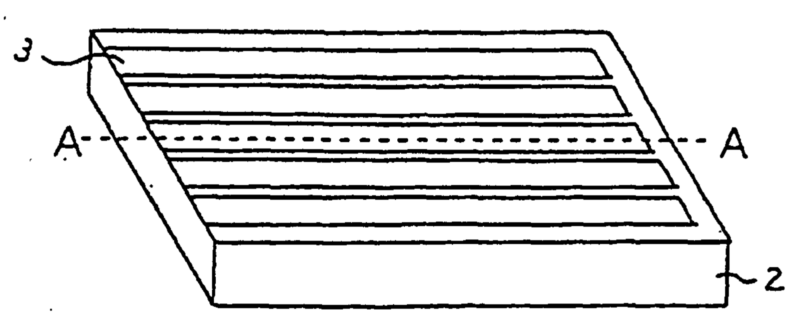


FIG.5A

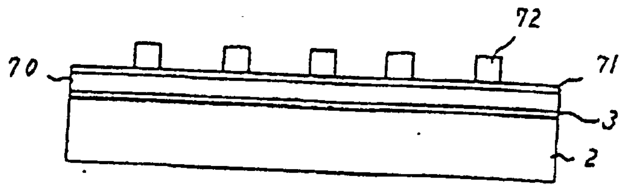


FIG.5B

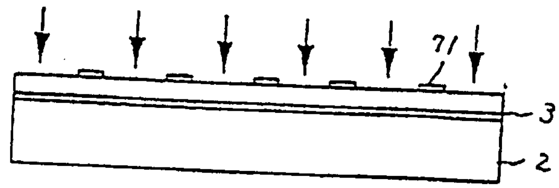


FIG.5C

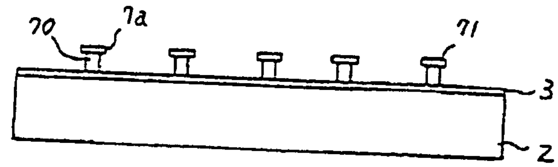


FIG.6A

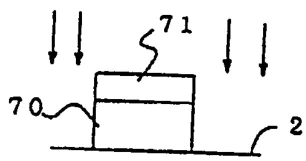


FIG.6B

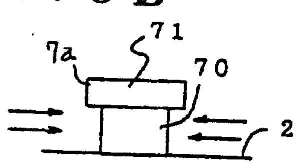
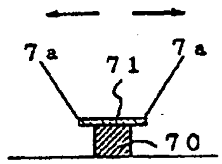
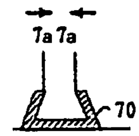


FIG. 7A



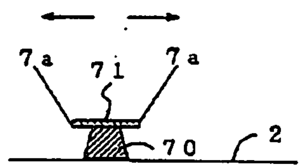
ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7E



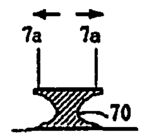
ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7B



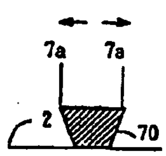
ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7F



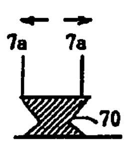
ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7C



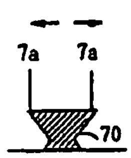
ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7G



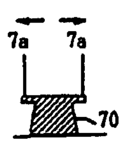
ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7D



ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG. 7H



ARROWS INDICATE DIRECTIONS
OF OVERHANGING PORTIONS

FIG.8A

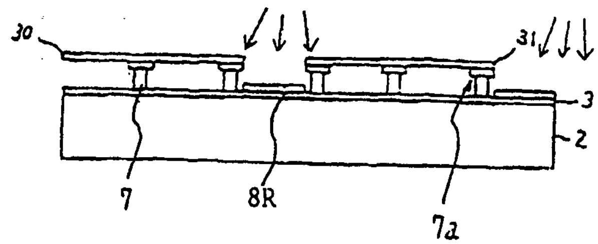


FIG.8B

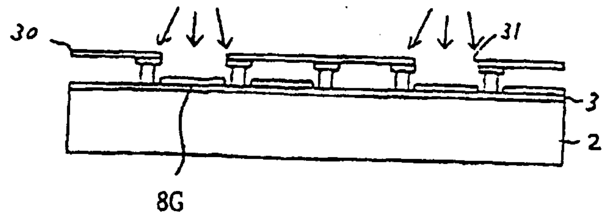


FIG.8C

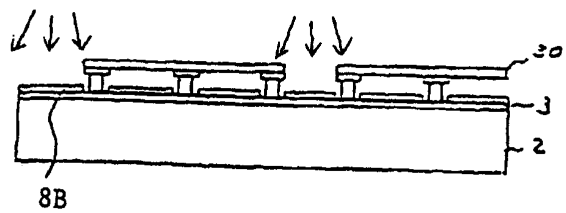


FIG.8D

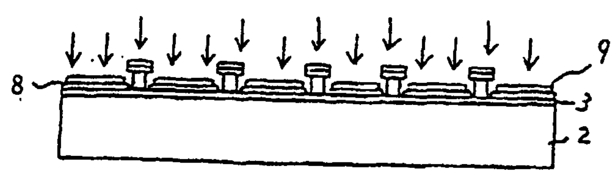


FIG.9A

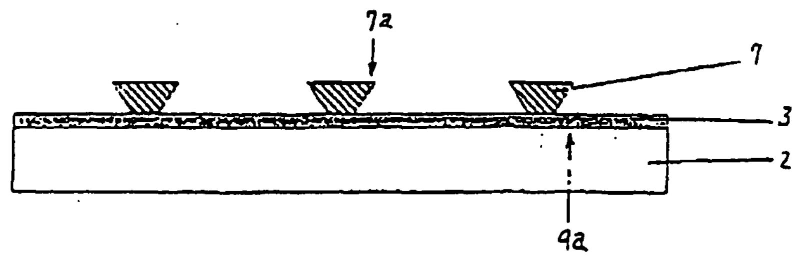


FIG.9B

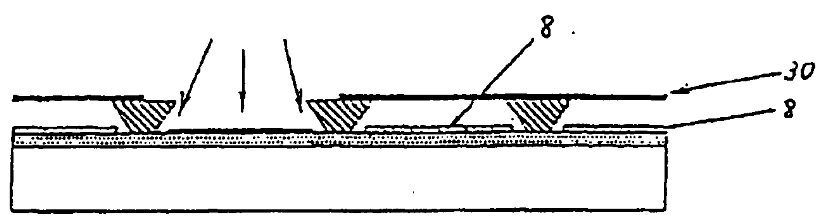


FIG.9C

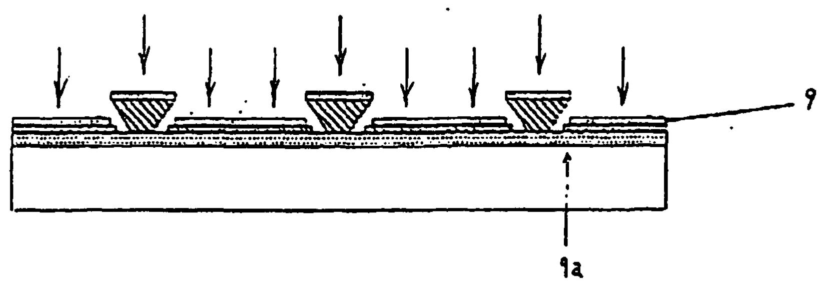


FIG. 10

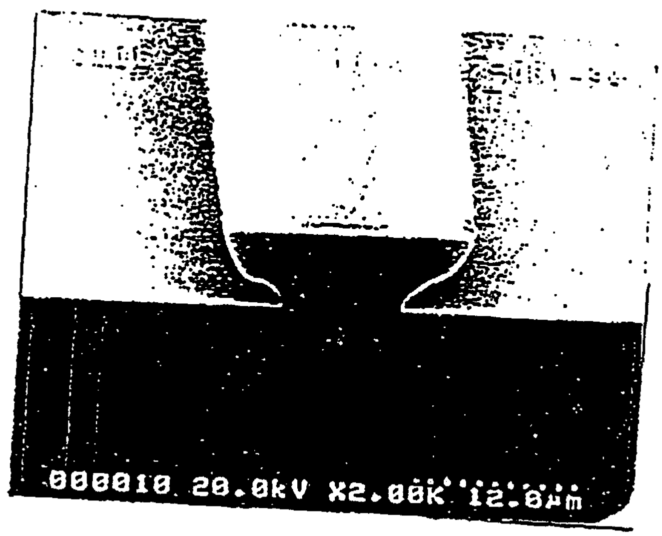
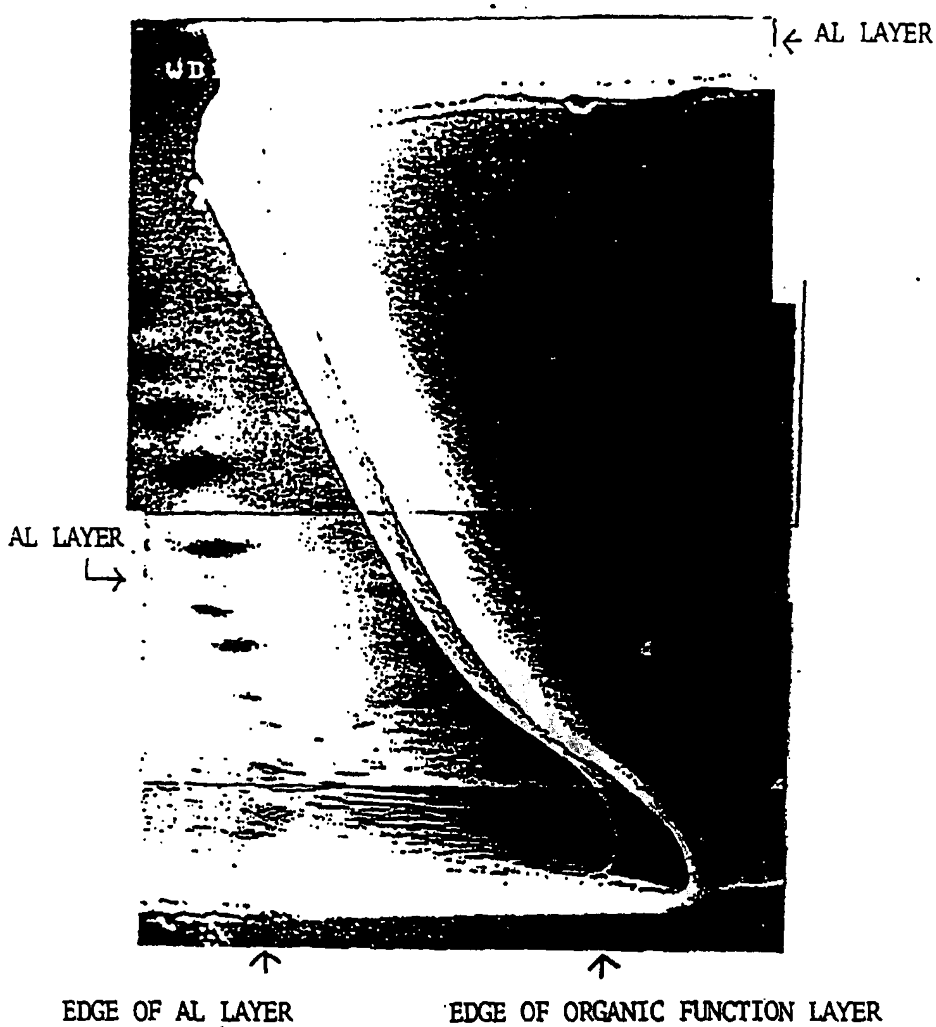


FIG. 11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EDGE OF ORGANIC FUNCTION LAYER

FIG. 12

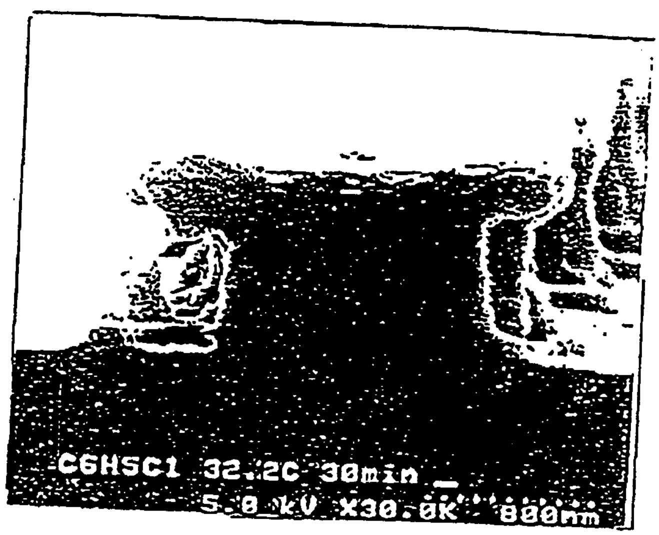

FIG. 13

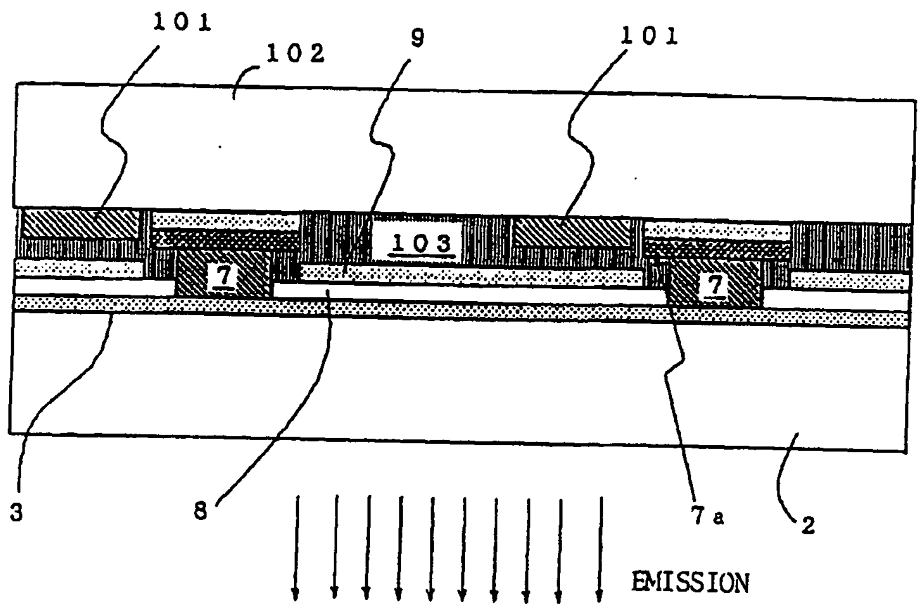

FIG.14A

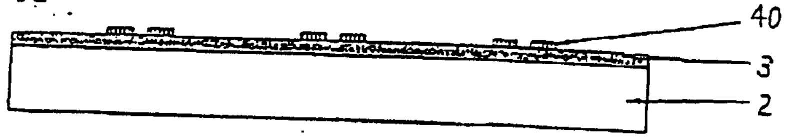

FIG.14B

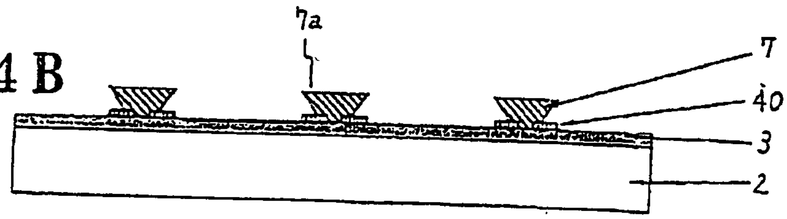

FIG.14C

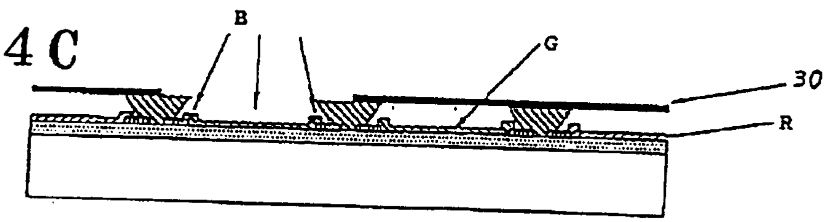

FIG.14D

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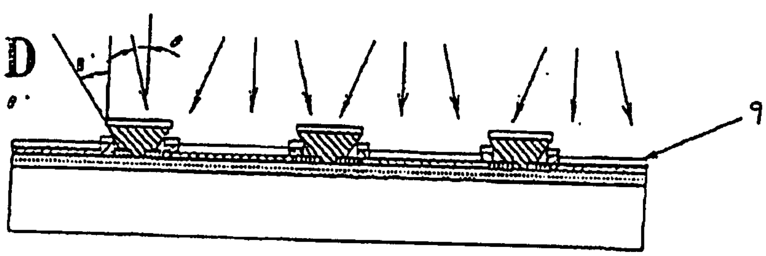

FIG. 15

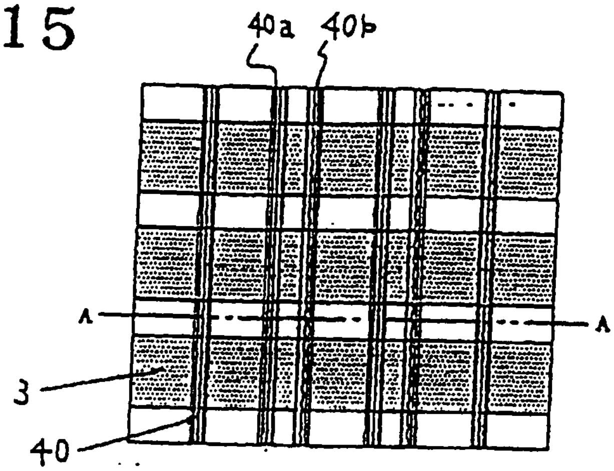

FIG. 16

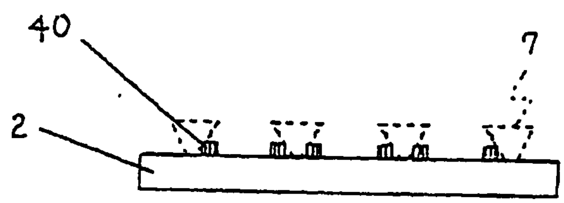

FIG. 17

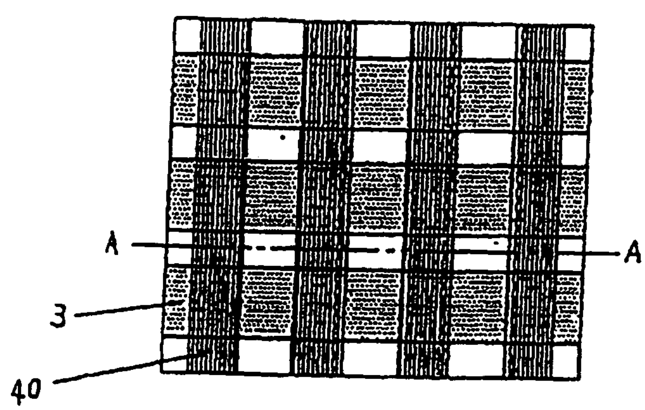

FIG. 18

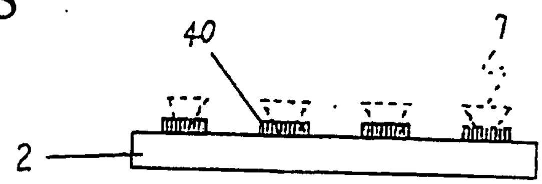

FIG. 19

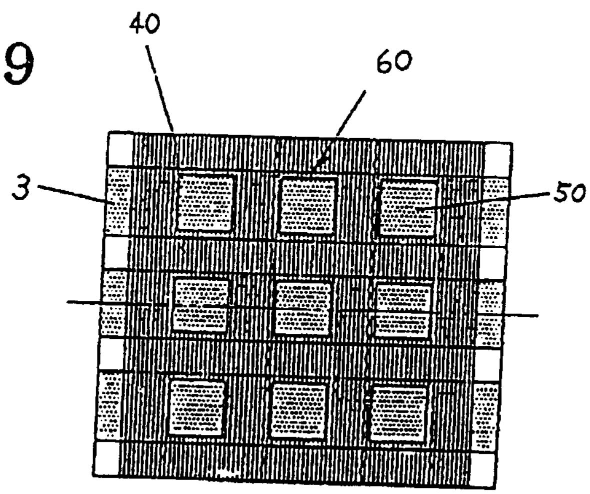

FIG. 20

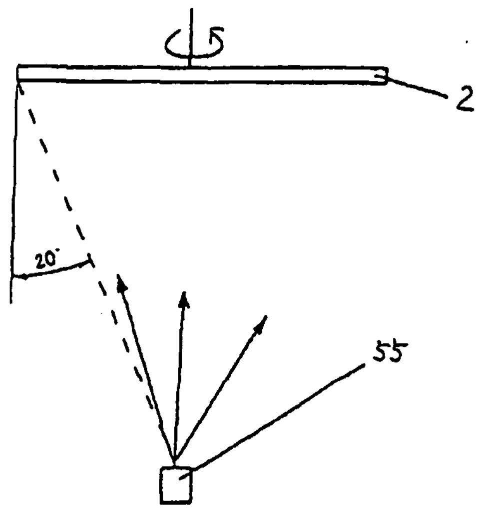

FIG. 21

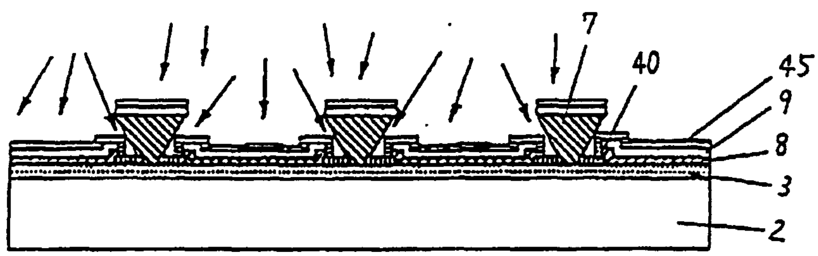

FIG. 22

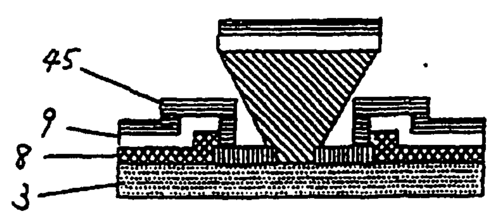

FIG. 23

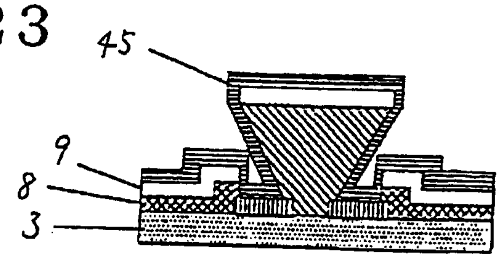

FIG.24

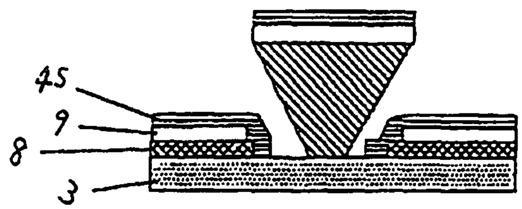

FIG.25